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COMMERCE AND DEEPWATERWAYS.*

BY PROF. LEWIS M. HAUPT, Consulting Engineer.

The lecturer was introduced by the Secretary of the Institute, and spoke as follows:

MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN:

In attempting to present a subject having so many phases, I shall endeavor to direct attention first, to the great economies and practical utilities resulting from a liberal public policy towards our river and harbor improvements; second, to the wonderful developments and benefits which have followed the successful deepening of some of the "highways of commerce," and third, to the methods which may be applied to secure the rapid and economical removal of the bars obstructing our waterways; touching incidentally upon the relations of coastwise to foreign commerce, the limita

* A lecture delivered before the Franklin Institute, December 13, 1895.

tions of draft to tonnage, the importance of shorter and deeper links connecting our great water systems, the incalculable losses due to insufficient water in natural channels, and the lessons furnished by experience, both at home and abroad, resulting from increased commercial facilities.

It has taken many years to impress the fact that the cheapest known method of transportation is by water, and that on the ocean the greatest economy is effected by the use of vessels of largest capacity. From this it follows that the price of every commodity imported or exported is affected by the size of the ship, and this in turn by the depth of water in the channels along her course. Hence the question of suitable depth becomes one of momentous importance to the commerce of the world, and often determines the supremacy of nations as of cities.

A few inches of sand across the ship's path imposes an effectual barrier to her progress, and may at times cause her entire destruction.

This question of the capacity of vessels is but another phase of the transportation problem, to secure the largest paying load at least cost for moving it, or, as it is more technically termed, the greatest ratio of live to dead load.

In rail transportation, the roadbed, rolling stock, stations, fuel, terminals and a host of employes constitute a large factor in the fixed charges (usually over 60 per cent.), while in water transportation, in natural channels, the roadbed is the free gift of God, the weight of the cargo and vessel is balanced by the buoyancy of the water, the fixed charges are relatively small, and the motor has merely to overcome the resistances of the air and water to the ship's passage through them. In many cases, as in rivers flowing to the sea, gravity provides the motor, and the cost of movement is hopelessly beyond reach of any figures possible in overland routes. For instance, the cost of transporting coal from Pittsburgh to New Orleans (2,000 miles) by the Ohio and Mississippi Rivers, including the return of empty barges, is accomplished at a profit to the carriers at 65 cents per ton, or $\frac{1}{3}$ mill per ton-mile, while the rate for the same coal from Pittsburgh to Lake Erie, with

millions of tons in transit annually, is 8 mills with transfer, or 6·93 mills without; this is 20·8 times as much as by the river. If the uncertainty of delivery by water, in consequence of the "tie-ups" occasioned by droughts, were removed, the cost of fuel on the river banks would give to the manufacturers of the valley a very great advantage over other competitors not so favorably situated.

The penalties paid for this uncertainty are enormous, as will presently be shown.

This rate of ⅛ mill per ton mile is, however, exceptionally low for an interior waterway in an unimproved condition throughout most of its course; yet the rate on the Great Lakes and on the ocean is even lower. Ocean freights are sometimes carried at ⅛ mill per ton mile, while the lowest paying rail rates are about 4 mills, the average charges being very nearly 9. So far as rail and ocean commerce are concerned, therefore, it is manifest that these two systems can never encroach the one upon the territory of the other, nor can they ever hope to compete in rates; but it must follow that the freight will remain aboard vessel and penetrate the inmost recesses of the land unless special inducements or rates are made by rail, or excessive pilotage or port charges cause an earlier transfer of cargo to the more expensive carrier.

It is this principle which has established, with few exceptions, all the great maritime cities of the world at the head of navigation of bays, rivers and estuaries. It has built Tyre, Venice, Marseilles, Amsterdam, Hamburg, Libau, London, Liverpool, Glasgow, Boston, New York, Philadelphia, Baltimore, Savannah, New Orleans, Galveston, Chicago, Duluth and many other terminals.

It is, in general terms, therefore, an error to carry export freights by rail beyond the first port at which they may be conveniently shipped, for with the difference in rates of 20 to 1 the short cut to tidewater is undoubtedly the cheapest for all parties. To carry the freight in cars beyond this point and to use so expensive a plant for storage purpose is, to say the least, an extravagant policy.

But it may happen that no suitable harbor or place of

transfer exists at the nearest point on tidal water, or that there are physical obstructions which render shipment both dangerous and expensive. At one of the Gulf ports, for instance, the cost of lighterage is stated to be $1.50 per ton, so that the charge for lading a 3,000 ton vessel in the "offing" would be $4,500. At the average rate of 9 mills per ton mile this freight could be hauled 166 miles further, provided it could then be shipped without lightering. In point of fact, much of it is carried over 300 miles further to New Orleans on the Mississippi, 113 miles from the sea, with towage and pilotage charges almost as great, doubtless to retain control of the freight and utilise the company's own terminals at this point. The cost of lighterage alone, at ocean rates, would carry the freight by sea 3,900 miles. Any port, therefore, that can secure a deep water channel over the bar, and thus eliminate these terminal expenses, and which is at the same time located near the centers of production, occupies a strategic commercial position, and hence it is that so much attention has been given by the Government to the Gulf coast, as being that which furnishes the shortest haul from the great grain fields of the West to the markets of the world as well as to our Eastern seaboard, and why money has been so lavishly spent at South Pass, Sabine Pass, Galveston and other places, to remove the bars obstructing commerce at these ports. Although $7,500,000 were spent by Capt. Jas. B. Eads and his associates in successfully deepening the South Pass to 30 feet, still the port and river charges constitute a barrier which limits the commercial movement of the Mississippi River, while at Galveston the struggle has been maintained with the sea for about a quarter of a century with the result that after spending probably $6,000,000, with more to follow, on jetties and dredging, a depth of only 19½ feet was reported as having been secured last October. The original depth over the outer bar was 12 to 12½ feet.

Here also the terminal charges for lightering over the bar have so restricted commerce as to have fully justified the lavish expenditure made in the effort to remove this persistent and difficult obstruction. But as the desired ultimate

depth of 30 feet has not yet been attained, Congress has granted special concessions to private parties to improve the mouth of the Brazos River and Aransas Pass, that, if possible, the people of the South and West might work out their own salvation contemporaneously with the Government effort. Under these Acts, contracts are now being executed at both of these ports, which will be referred to later, our attention being confined at present to the benefits and economies of deep water in general.

The more deeply this phase of the subject is investigated, the more impressive becomes the conviction that the stimulus given to commerce by the deepening of her waterways is the basis of national prosperity. This conclusion gives to the appropriation for this purpose a pre-eminence over all others, and justifies, to the fullest extent, the levying of special taxes if necessary for this purpose. This policy is pursued by foreign countries with the most beneficial results, and it is carried so far as to subsidise steamship lines to develop new avenues of trade without opposition.

In 1892, the chairman of the Senate Committee on Commerce reported that "the total expenditure for water improvements on the lakes has amounted to about $30,000,000, approximately one-fifth of the annual saving effected in transportation. By the improvement of these great waterways freights have decreased from 15¾ cents a bushel for corn between Chicago and Buffalo in 1859, to 1·9 cents in 1890. Since then it has been carried for 1 cent per bushel for these 1,000 miles, and the tendencies are still lower.

In this country, a narrow partisanship condemns such propositions as unjustifiable prodigality, while conflicting transportation companies oppose the enlargement of our waterways on principle, erroneously assuming that they are injurious competitors.

These opposing forces will account for the comparatively undeveloped condition of our internal waterways. A few extracts from the testimony, taken by the Cullom Committee on Interstate Commerce, will serve to reveal some of the actual causes obstructing our commerce.

Mr. F. B. Thurber, of the New York Board of Trade, said:

"Canals should be modernised. For twenty-five or thirty years they have remained just as they were. * * * The water lines are, I may say, the salvation of this country, and should be developed and extended in every possible way. * * * The railroads have improved enormously, while little or no improvements have been made in our system of American waterways. * * * This is doubtless largely to be attributed to the adverse influence of railroad corporations in legislation. In Pennsylvania and other States they have bought up the canals and abolished them. Whenever a river and harbor bill is pending in Congress, the railroad representatives will vote millions for improvements which do not materially affect them; but when it comes to an item like the Hennepin Canal, which promises to be of benefit in extending our system of waterways, they are found voting solidly against it," etc.

Mr. Chas. Ridgely, President of the Springfield Iron Company, said, in regard to the importance of developing water-routes: "The cost of such improvements would come back to the people many times over, in the reduced rates of freight which they would secure, even if all the freight went, as now, by rail, and the canals were unused."

Hon. Thos. Updegraff, of Iowa: "I have more faith in water routes as cheapeners of transportation on interstate commerce than in all suggested means."

This is the general purport of some 90 witnesses, of whom 80 per cent. was in favor of improving our internal waterways, 17 per cent. was opposed, and 3 per cent. undecided. Of the 15 persons opposed, 10 were railroad officials, 3 farmers, 1 merchant and 1 machinist.

But the opinion entertained by some railroad managers as to the injurious effects of parallel waterways is giving place to the more enlightened belief that such competition is beneficial. This is evinced by many of the most prosperous railroad managers in this and other countries. While it is a very important factor in the commercial development of our resources, it is too broad to be considered at this time, and must be dismissed with the suggestion that the stock quotations taken in connection with the geographical position of the roads will serve to illustrate its truth.

RATES BY COUNTRY ROADS.

In strong contrast with the rates by water, as previously mentioned, it may be well to observe, in passing, the semi-official results recently reported by General Roy Stone, special agent of the Road Inquiry Office, concerning the cost of freight movements over our road system in various sections of the country. "The average cost of haulage over the roads in the United States is 25 cents per ton mile; in New England it is 32 cents; in the Middle and Southern States, 31 cents; in the Northern States, 27, and in the prairie country, 22 cents. The average length of haul in the Northern States is 6·9 miles, so that the total cost of the haul is $1.86 for each ton."

The total cost of the movement of our farm products reaches nearly $1,000,000,000, of which nearly two-thirds might be saved by merely improving the roads. There are many places where the rehabilitation of our canals would reduce this tax upon commerce still further, and, by increasing the ratio of water to land carriage, lower the through rate, while still giving the railroad a larger percentage of the tariff than it can now secure, and at the same time increase its tonnage and shorten its haul. Mr. Stone says: "We are handicapped in all the markets of the world by the enormous waste of labor in the primary transportation of our products and manufactures, while our home markets are restricted by difficulties in rural distribution which not infrequently clog all the channels of transportation, trade and finance."

Another benefit resulting from deeper internal waterways would be the increase in the amount and value of our exports, thus converting a deficit into a surplus, and making us a creditor instead of a debtor, paying our balances in goods and products instead of in gold, and stimulating our manufactures by the lower price of raw material provided from the home market. It thus extends its beneficent influences beyond the limits of the nation and assumes an international importance. These generalities are abundantly illustrated in the case of France, Germany and other countries.

RELATION OF DOMESTIC TO FOREIGN COMMERCE.

The internal commerce of a country is the basis of the external, and as its relative importance does not appear to be generally recognised, a few words in relation thereto may not be amiss. It is commonly believed that the foreign tonnage is the largest and most valuable adjunct to a seaport.

This fallacy doubtless arises from the fact that every ton of imports or exports is recorded, as most of it is taxed for

revenues, and its value is carefully appraised, while the domestic tonnage is not generally reported, and the difficulty of securing statistics of this movement from official and reliable sources is very great; yet a careful examination of the reports of the various Boards of Trade, Census Reports, and other documents, leads to the conclusion that the domestic tonnage is not far from 75 per cent. of the entire tonnage of most of our ports. Taking our own case for example, we find that in 1892 the gross tonnage of Philadelphia was 14,572,292 tons, of which 3,788,781 only was foreign, or 25 per cent. In 1893 the total was 13,326,484 tons, of which 2,971,111, or only 22 per cent., was foreign. The rest, or 78 per cent., was coastwise. Of this traffic over 5,000,000 tons was coal, and about 1,000,000 petroleum.

In 1870 it was stated that the domestic commerce through the limited Delaware and Raritan Canal exceeded all the foreign tonnage to and from New York for that year.* Since then the foreign commerce of New York has expanded enormously, while the canals have been contracted by the failure to recognise their utilities and economies, and to enlarge their capacities to keep pace with the demands of modern vessels.

Another question of considerable importance, viz.:

THE RELATION OF DRAFT TO TONNAGE,

arises in connection with the projects to enlarge existing waterways. It is one which is almost indeterminate, since it grows with the additional facilities afforded. The tendency to cheapen transportation by carriage in bulk causes ship-owners to build larger vessels in anticipation of deeper drafts. On this point the late General O. M. Poe said:

"For thirty-five years I have watched the increase of the Great Lakes' commerce, but neither I nor any one else has been able to expand in ideas at the same rate. The wildest expectations of one year seem absurdly tame by the side of the actual facts of the next."

This statement is fully confirmed by the fact that in 1840

* Testimony of Gen. I. Wister before Interstate Commerce Committee.

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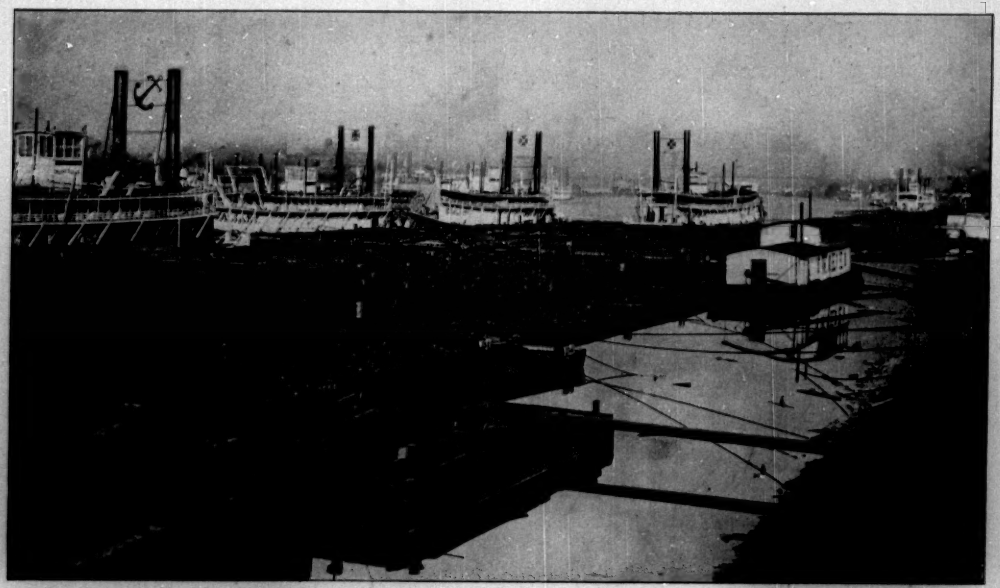

NAVIGATION ON OHIO SUSPENDED BY DROUGHT FROM APRIL UNTIL DECEMBER, 1895.—1,200,000 TONS OF COAL. VALUE OF PLANT OVER $6,000,000. DAILY EXPENSE OF KEEPING IT AFLOAT, $2,000.

COAL TOWS IN THE DAVIS ISLAND POOL ON THE OHIO RIVER—AWAITING A "RISE" TO GO OUT.

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Henry Clay denounced the Sault Canal project as "a work beyond the remotest settlement in the United States, if not in the moon," and yet the locks have since been enlarged thrice to accommodate the rapid strides in the traffic.

Last year the tonnage exceeded 13,000,000, yet the opening of the Canadian locks, by affording increased facilities, has enabled about 15,000,000 tons to be passed during the current year, which merely proves the old adage that *facilities create traffic*. By "facilities" is to be understood any economy resulting from reduced distances or time in transit, or at terminals, or from reduced rates.

The relation between draft and tonnage is more fully set forth in the annexed communication to the Board of Engineers appointed to select the best route from Baltimore to the sea.

UNITED STATES CUSTOM HOUSE,
BALTIMORE, November 26, 1894.

Thos. L. Casey, Brigadier-General, Chairman, Chesapeake and Delaware Canal Board, Washington, D. C.:

* * * The draft of vessels is not made a matter of record in this office, and I have, after consulting with competent persons, arranged the number of vessels embraced in the foregoing statement into four groups under certain respective drafts, which will probably serve as a guide to your deliberations.

I will also state that there is a large number of vessels engaged in the coasting trade, between this and other domestic ports, that are not obliged to enter or clear at the Custom House, representing as much as 2,000,000 tons, about 75 per cent. of which go North and bear the same relative proportion as to draft.

[SIGNED] JAS. A. DIFFENBAUGH,
Special Deputy Collector.

This is followed by a tabular statement of tonnage, foreign and coastwise, for several years, from which the following data are collated:

COASTWISE MOVEMENT FOR 1893 FOR PORT OF BALTIMORE.

	Under 10′ Draft.	10′ to 15′ Draft.	15′ to 20′.	Over 20′.	Total Reported at Custom House.
	Tons.	Tons.	Tons.	Tons.	
To and from Northern cities	29,911	145,641	487,754	205,937	868,543
Percentage	3%	17%	56%	24%	100%

It will be seen that *only 3 per cent.* is carried in vessels drawing 10 feet of water, while by far the greater portion

requires from 15 to 20 feet, and that a depth of 20 feet would pass 75 per cent. of the tonnage. If the nondescript tonnage is 2,000,000, as stated for Baltimore alone, and we take 75 per cent. of it, or 1,500,000, and add it to the recorded tonnage alone, it gives a total movement from this one port for the year of 2,368,543 tons to and from *Northern* cities.

The domestic commerce of Delaware Bay and tributary waters, as reported by the various custom districts, after deducting 25 per cent. for foreign commerce, is 14,250,000 tons, while that of the Chesapeake Bay is 11,250,000 tons, making a total of 25,500,000 tons.

If 3 per cent. represents the limit of the present 10-foot canal it would equal 765,000 tons, which will be found to be about the average tonnage of the Chesapeake and Delaware Canal in the past ten years.

Were this canal deepened to 15 feet, it would then be able to pass 20 per cent., or 5,100,000 tons, and 20 feet would give it a capacity of 75 per cent., or 18,125,000 tons.

With this amount of commerce in sight at present, it is manifest that a very great reduction in rates could be allowed, and still leave a handsome profit to the owners.

Fifteen feet draft, or 5,000,000 tons at 20 cents, would yield a revenue of $1,000,000, and for an open waterway at tide level it would cost but little more to handle 5,000,000 than one-tenth this amount, so that the excess would be profit, and the rates could be reduced to a minimum, to great advantage to the commercial interests of this populous section. At 1 cent per ton mile, or 14 cents for the trip (which is still a high rate for canals) the revenue would be $700,000, the interest at 6 per cent. on $11,666,566, whereas the cost of the work with modern devices should not exceed $2,000,000.

An open waterway once built requires the minimum of expenditure for maintenance and operation, and the fixed charges are practically independent of the tonnage.

This work of enlargement, if undertaken, with the co-operation of the Government, would prove to be one of the most beneficent and profitable enterprises of our times, and would commend itself to all enterprising and public-spirited

citizens. It would restore in great measure the declining commerce of this port, and increase the profitable tonnage of all railroads having terminals in these waters, by stimulating manufactures and increasing the ratio of growth.

Stevenson says the commercial value of a waterway increases as the cube of the depth, so that if the depth be doubled its value will be eightfold greater. This law must be restricted, however, within practical limits.

THE TYNE, ENGLAND.

Let us now note a few special instances of the benefits resulting from the deepening of waterways, and their results upon the adjacent territory, taking first one of the many valuable and instructive foreign precedents.

A case which is often cited, but which will bear repetition because of its moral, is that of the River Tyne, on the east coast of England. It is but a short stream extending from New Castle to the sea, about 19 miles of which are in tidal waters. In its original condition it was little better than a creek, and vessels were often stranded on the bars in 3 feet depths at low water. Frequently vessels drawing 17 or 18 feet were obliged to wait two or three months for favorable spring tides and winds to enable them to cross the bar; yet now the largest ships afloat can safely navigate this stream without detention at any stage of the tide. To secure this result, the sum of $20,000,000 has been spent by the Tyne Commission in dredging, building training-walls, piers and dry docks, and in providing warehouses and terminals. From 1860 to 1887 over 80,000,000 yards were dredged. At the beginning of the work the revenues derived from tolls and tonnage dues were far from sufficient to provide for the annual expense, and it became necessary either to borrow the money or permit the shipping to seek other ports having better facilities.

It was decided to borrow, and up to the end of 1882 the work was conducted on loans, which aggregated $18,365,000. Only $2,130,000 was expended out of revenue received from shipping. The result, however, has fully justified this policy, as the annual income has grown in 20 years from $455,000

to over $1,255,000. The results of these improvements, which have produced a depth of 30 feet, have been remarkable. In 1888 nearly 21,000 vessels entered and cleared, carrying 8,396,000 tons, which is about equal to the commerce of the Suez Canal. These improvements were not made by the Government, but under the admirable system of public works existing in Great Britain, which authorises local harbor commissions to levy a tonnage tax upon vessels, and to apply the revenues derived therefrom directly to the maintenance and improvement of the harbors. Thus, under the presidency of Sir Joseph Cowen and his Board, aided by their resident engineer, Mr. Philip J. Messent, to whom I am under obligation for many valuable data, these works have been successfully executed with so great benefit to the commerce and industries of that thrifty and popular center. A trip to Tynemouth reveals a succession of shipyards, warehouses, mills, factories, towns and cities skirting both banks of the river, which is almost unparalleled in the world, all due to the increase of depth in the river and on the bar to 30 feet mean low water.

THE OHIO, BELOW PITTSBURGH.

Per contra, as in art, so in engineering, it often requires negative to produce positive results. The sinking of a propeller in the channel below the locks at the Sault so obstructed commerce as to leave no doubt about the propriety of still further enlargements in that direction.

The blockade of our seaports in 1813–14, and the destruction and sacking of the National Capital impressed upon our forefathers the importance of connecting the Chesapeake, Delaware and Raritan Bays by canals; and in the event of a war to-day with any foreign power, the absence of a passage for our heaviest gunboats would seriously cripple our defences and expose our coastwise cities to destruction. If the mere edict to construct such waterways could bring them into existence in a moment, it would then be issued, be the cost what it might, "but it would then be too late."*

* Gen. Wm. P. Craighill, U.S.E.

One of the most impressive lessons to be derived from the absence of sufficient water for commerce is to be found in the experience of the communities on the upper Ohio River during the past season of exceptional drought.

The harbor of Pittsburgh, which is made by the movable dam at Davis Island, and the fixed dams of the Monongahela slackwater system forms a convenient basis in which to make up the tows of coal boats and barges which supply the Mississippi and its tributaries.

It is the custom to assemble these tows above the dam and await the pleasure of Pluvius to provide a flood with sufficient depth of water to carry them out. Sometimes the river rises to within a few inches of the requisite height, and then provokingly subsides. During the past season there has been no coal shipped by river between the 18th of April and the 28th of November (over seven months), and the accumulation of the product had gone on until the tonnage tied up exceeded that of any harbor in the world. For miles on both banks of the river the steamers and their fleets lined the shores, and the danger of their being frozen in all winter was imminent, when a heavy rain released 200,000 tons; but a part of these met a watery grave on the shoals of Dead Man's Ripple, a short distance below Pittsburgh.*

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* *Quantities of Fruit Going to Waste.*—The Ohio River lower than it has been since 1860, with one exception.—Distilleries in Kentucky affected.

CINCINNATI, O., Oct. 15.—Millions of bushels of fruit are going to waste along the Ohio River, because of the close of navigation. Between this city and Evansville, 250,000 barrels of apples, in addition to potatoes and other produce, will be lost by decay.

At the little port of Amsterdam, Ind., 2,000 barrels of apples have been lying on the wharf for two weeks awaiting shipment.

The river is lower now than it has been since 1860, with one exception.

The continued drought in Central Kentucky is interfering seriously with the distillers. Glen's Creek, which is the only source of water supply for several distilleries, has gone dry, and a large number of men are out of employment.—*Ledger, October 16, 1895.*

* *Mishaps to Barges.*—Fifteen that were carrying coal sunk, and eight more are aground.

PITTSBURGH, November 28.—Nearly 5,000,000 bushels of coal was started down the river to-day, making a total going out on this rise of about 15,000,000 bushels. The river is now receding rapidly, and as there is no present

The extent of this congestion cannot be appreciated by one who has not seen it, and it is far-reaching in its effects, as it directly concerns the industries of millions of people. The actual value of the plant tied up in the harbor of Pittsburgh alone, as stated by Hon. John F. Dravo, Secretary of the Coal Exchange, on November 7th, 1895, was $6,310,000, as follows: "There are at the present time in Pittsburgh harbor about 1,200,000 tons of coal loaded on about 2,500 vessels:

2,500 vessels, average cost $900	$2,250,000
Cost of coal in Pittsburgh harbor	1,260,000
There are registered in this port about 80 towing steamers, average value, $30,000	2,400,000
Twenty passenger and other steamers, average value, $20,000	400,000
	$6,310,000

"At the present time it is costing about $2,000 per day to keep this tonnage afloat, besides interest on the investment."

Two thousand dollars per day is the interest on $40,000 at 5 per cent. In one month it represents $1,200,000—merely to keep the tows afloat, which is done by sprinkling sawdust over the surface of the river around the boats and pumping out the seepage from the interior. This "tie-up" of Nature has seriously crippled the entire valley, as the railroads cannot do more than maintain a partial supply, and the price of fuel has risen in some of the larger cities $1.00 a ton.

These are but a few of the consequent evils resulting

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prospect of more water, the tows with 7-feet boats will, of necessity, have to tie up along the route before reaching Cincinnati.

A wreck at Dead Man's Island, near Sewickley, last night, caused a loss of about 250,000 bushels, involving the sinking of fifteen barges. The *Relief* grounded a barge, and the four other tugs, with barges following close in their wake, were piled up one after another in a confused mass. The channel, however, was cleared sufficiently to permit the tows leaving to-day to pass through safely.

The *Iron Age*, towing eight barges of iron and steel for Cairo, is aground at Freedom, and up to a late hour to-night had not succeeded in getting off. Her cargo represents about $240,000.—*Times, November 29, 1895.*

from the unimproved condition of the upper Ohio, which has been crying for relief for half a century.

As yet only the one dam is completed, at Davis' Island, 5½ miles below Pittsburgh, although another is now under contract at Beaver, some 23 miles below the first, leaving between the two a long stretch of unimproved navigation. These dams cost about $1,000,000 apiece. In contrast with this state of affairs, reference may be made to the work of improving the Great Kanawha by a similar system of movable dams, under the continuous supervision of General Wm. P. Craighill, now Chief of Engineers. Here the system will soon be completed, and will furnish a 6-foot navigation to Brownsville, with the result that, while the commerce of the river has greatly increased, that of the railroads has, contrary to their expectation, been expanded in like ratio. Nor is this an isolated instance where the improvement of the waterways has proven beneficial to railway traffic. In fact, the experience is general, and it is no uncommon thing to find railroads hauling crude products at a loss to maintain the traffic resulting from their use in manufactures.

Between the lowest profitable rate by rail and by water, there is a large margin for movement of raw materials by canals, which cannot be profitably handled otherwise, and which, but for the cheaper water rates, must lie dormant in the earth at the expense of their dependent industries.

For example, by a suitable waterway from the coal regions of western Pennsylvania to Lake Erie, which is now felt to be a necessity, it is found that "bituminous coal can be delivered in Chicago at $1.61½ per ton; in Duluth, at $1.50½; Detroit, at $1.38; to Canadian vessels at the head of the Welland Canal, at $1.20; and in New York City, via the Erie Canal, at $1.98; and the secretary of the Pittsburgh Canal Committee, Mr. John E. Shaw, adds that the economy on coal alone in six leading cities of the lake region would amount to $12,000,000 annually, representing, at 4 per cent., the interest on $300,000,000."

"A comparison of the selling price of bituminous coal in the lake and Canadian cities and New York harbor, will

make apparent the commercial benefit from these proposed deep waterways.

"That the present or any proposed railroad system of overland carriage by rail can never bring about this enormous saving to commerce is also apparent.

"There are nine railroads operating wholly or in part between Pittsburgh and the Great Lakes. The total cost of road and equipment of these lines is $172,141,738.82. The average ton mile rate on all freight on said lines is about 6½ mills, which is below the ton mile rate on the ore and coal to and from the Pittsburgh district, and yet the financial statements of four of these roads has recently shown a net loss on their business; and as the lowest class of traffic has required a ton mile rate below the average of total freight carried, it is not hard to see that it would have been business economy for these railroads to have put a sufficient amount of the enormous cost of their roads into a canal and had it relieve them of this low-class freight."

Some idea of the economies resulting from this proposed deep water canal, as based upon existing tonnage, may be obtained from the following statistics compiled by Mr. Shaw:

A saving of 77 cents per ton on the ore required for Allegheny County would be	$3,196,093 60
For Mahoning and Shenango Valleys it would be	1,382,875 14
Making a total of	$4,578,968 74
While the amount earned by the canal in carrying this ore at 35 and 15 cents, respectively, would aggregate	$1,455,998 85
The coal now shipped from western Pennsylvania to lake ports amounts to 7,761,891 tons, on which, at 72 cents per ton saved, the economy would be	5,588,861 58
At 30 cents per ton for transportation, the canal returns from this amount of coal would be	1,553,378 20
Or a total saved on the price of ore and coal at the points of consumption of	10,167,530 32
And a total earned for the canal of	3,009,379 05

Being 6 per cent. on $50,000,000 from coal and ore alone.

A conservative estimate of the tonnage which would traverse this canal, if opened to-day to a depth of 15 feet, would be:

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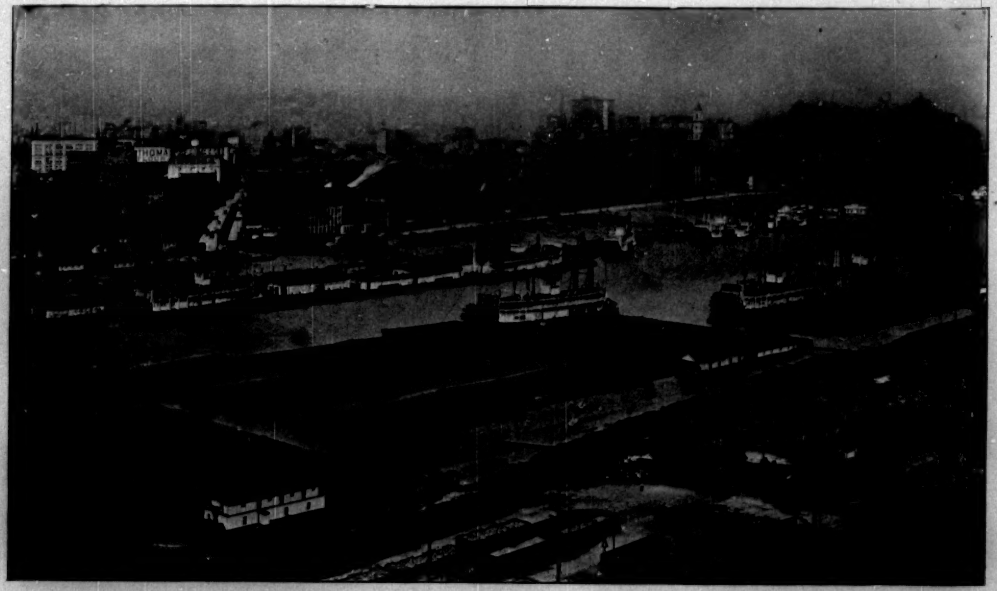
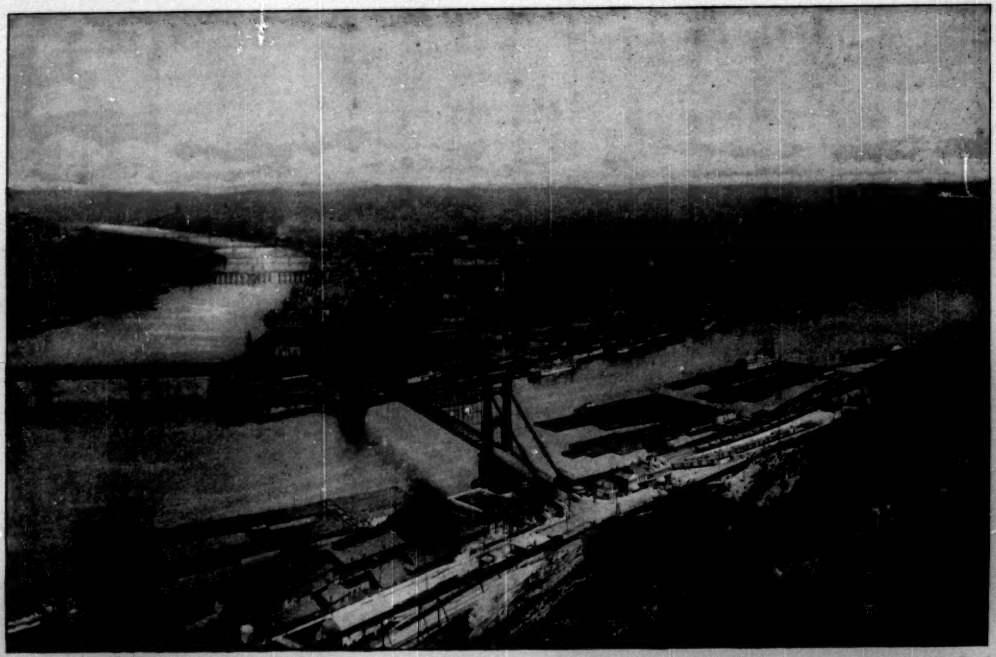


PORTION OF PITTSBURGH HARBOR WITH COAL FLEETS, LINING BOTH BANKS OF THE MONONGAHELA RIVER.



JUNCTION OF THE ALLEGHENY AND MONONGAHELA RIVERS FORMING THE OHIO AT PITTSBURGH, PA.

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	Tons.
Ore	6,000,000
Coal	7,000,000
Limestone and miscellaneous	1,000,000
Coke and lumber	1,000,000
	15,000,000

At an average rate of 30 cents per ton, therefore, the revenue would be $4,500,000, while the economy effected each year in transportation would exceed $10,000,000. As there are many persons whose interests in other securities make them skeptical concerning such estimates as these on paper, it may be advisable to refer to the experience of the Suez Canal, which was so bitterly opposed by British diplomats, engineers and the press while in French hands. Now, however, since the control has crossed the English Channel, we find, in 1894, the gross receipts of the company were $15,390,230.60, as compared with $14,764,906.80 in 1893, and if the revenue from the tramway from Port Said to Ismalia and the lands and water company are eliminated, it will be found that the actual receipts from the vessels that used the canal were $650,800 higher than in the previous year. Expenses were $65,958.60 smaller than in 1893. Taking the whole of the charges of every kind, including the interest and sinking fund on the bonds, the 5 per cent. interest which is paid on the whole of the capital, and a sum of $90,000 for renewals and improvements, we get a total of $7,165,834.20, which, deducted from the gross revenue of $15,390,230.60, leaves $8,224,396.40. Out of this sum the council recommended the placing of $150,931.60 to the reserve, thus bringing it up to $1,150,931.60. Thus there remained for distribution among the shareholders $8,073,464.60, and each share, in addition to the 5 per cent., which is first paid, will receive for 1894 a dividend of $14.20. The gross yield on Suez Canal shares for last year consequently comes to $19.20, or 18 per cent., or, after deducting the tax, to $18 net. Tolls are now $1.85 per ton for the 100 miles.*

[*To be concluded.*]

* Consular Reports.

THE BUILDING STONES OF THE UNITED STATES.*

BY DR. WM. C. DAY.

The lecturer was introduced by the Secretary of the Institute, and spoke as follows:

MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN:

It is my privilege this evening to call your attention to some of the more important features of the stone industry in the United States.

When we think of stone in relation to the uses to which it is put, we are inclined to look upon it as a building material, and while its application as such is, to be sure, more important than any other, we should not forget that there are other uses which the term building stone, in its proper sense, does not in the least suggest.

For example, stone for building, road-making, blast-furnace flux, and lime-burning, is frequently taken from one and the same quarry, and the particular one of the uses named, to which the stone is devoted at any given time, may simply be a question of demand for the time being.

While, from the strictly scientific standpoint, quite a large number of different kinds of stone are distinguished by separate names, from the commercial point of view, the number of distinctions is reduced, mainly for expediency, to six; these are: granite, sandstone, bluestone, limestone, marble and slate.

The term granite, which, scientifically, is definitely limited in meaning, is commercially used to include a number of varieties for which the scientific term, crystalline silicious rocks, would be more correct and sufficiently comprehensive. Among quarrymen producing the crystalline silicious rocks, the term granite is made to do a rather extended duty, and no fine distinctions of variety are recognised.

Sandstone is, commercially, a very different thing from the bluestone extensively quarried in New York, Pennsyl-

* A lecture delivered before the Franklin Institute.

vania and New Jersey, and used chiefly for curbing, flagging and paving in our large cities. The bluestone referred to is, however, simply a sub-variety of sandstone, and yet, if you were to tell a bluestone producer that he was quarrying sandstone, he would be inclined to smile at your supposed ignorance.

While limestone and marble are chemically the same thing, namely, carbonate of calcium, or a mixture of carbonates of calcium and magnesium, physically, they are very different, and the widest possible difference exists in the uses to which they are put, and in the prices which they command.

In the stone trade, quite a number of names are in use which have merely a local significance, and which may, or may not, give an idea as to the nature of the stone. Thus, the name Conshohocken stone tells a Philadelphian at once what the material in question is, but it would probably mean much less to the resident of Chicago or St. Louis.

Stone, forming as it does so large a constituent of the earth's crust, is almost universally distributed; and when, in almost any locality, it is needed for ordinary foundation, building or road-making, it can be found ready at hand. When, however, we take into account considerations of durability, strength, beauty, capability of withstanding sudden changes of temperature, power to resist atmospheric agencies, etc., we may find that a stone capable of fulfilling all, or, indeed, only a few, of these conditions, must be brought from a distant locality. It thus happens that stone suitable for certain uses occurs naturally in a few spots only throughout our large country. This statement applies especially to marble, slate and the best varieties of granite.

Stone, in its natural bed in the earth, has, as a rule, but little value, and property which is supposed to contain even the more valuable kinds of stone may be purchased at a figure little, if any, above that which it commands for agricultural purposes.

Since, further, the land capable of yielding desirable stone is, in the majority of cases, for that very reason, unfit

for cultivation, the price of undeveloped quarry property is often quite low. The high prices which stone often commands in the market are due to expenses of quarrying and dressing, and to transportation charges.

Historically considered, the stone-quarrying industry in this country dates back only to about the beginning of the present century, although stone, previous to this date, had been used, to a limited extent, for building purposes. The house of Deacon John Phillips, in Boston, built of granite boulders taken from the immediate vicinity, was erected about the year 1650, and it continued to stand until 1864. In the same city, the old Hancock house, since destroyed, was built in 1737, of Braintree granite, and between 1749 and 1754, also King's Chapel, still standing on the corner of School and Tremont Streets.

Previous to this, the granite boulders to be found in the neighborhood of Quincy had been used for minor purposes for some years, free of charge, until at last the inhabitants, assembled in town meeting, decreed that no person shall dig or carry off any stone on the said commons, or undivided lands, upon any account whatever, without license from the committee, upon penalty of the forfeiture of 10 shillings for every and each cartload so dug and carried away.

In 1825, quarries were opened at Quincy for the purpose of supplying granite for the construction of Bunker Hill Monument, and it is from this time that the business of quarrying granite assumed any real importance. While the Massachusetts quarries were the first to obtain granite systematically for building purposes, gneiss for curbing and paving was taken from quarries at Haddam Neck, Conn., as early as 1792. The product was used chiefly in Boston, New York, Albany and Baltimore.

The ready facilities of transportation by water to all of the important cities on the Atlantic Coast, and the excellent quality of the stone to be found on the coast of Maine, caused operations in this State to be started soon after the establishment of quarries at Quincy, Mass.

The quarrying of marble is said to have begun at New Milford, Conn., in 1800. Operations were actively carried

on here for some years, but competition in Rutland, Vt., caused the shutting down of all operations in 1850.

Sandstone quarrying was conducted in 1665 at Middletown, Conn., operations being free to all until the townspeople decided to impose a tribute payable in wheat and peas for all stone taken away. The sandstone deposits were later acquired by purchase, and quarrying operations were very active between 1810 and 1820.

Slate quarries at Slateford, Pa., were opened in 1812. Slate quarrying in Vermont did not begin until 1845, when the manufacture of school slates was undertaken at Fair Haven.

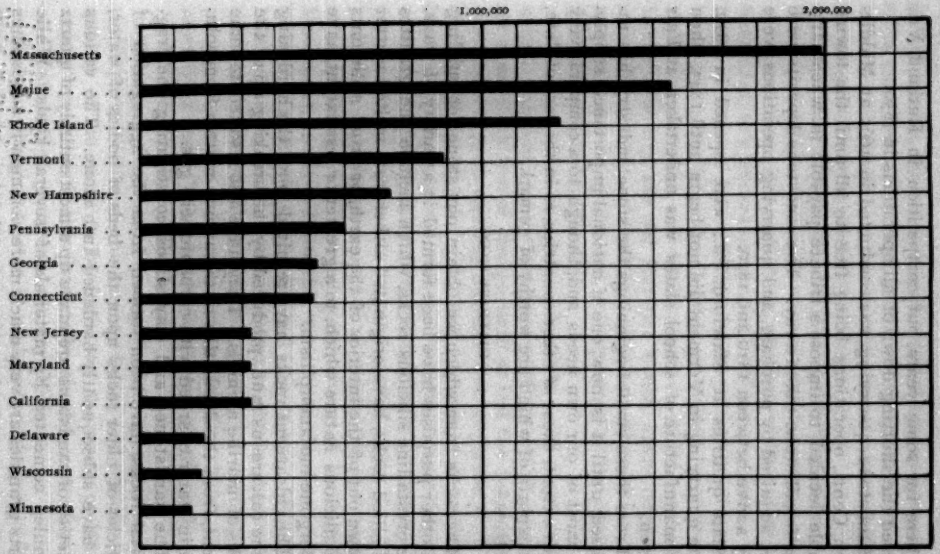
From these small beginnings the stone industry has increased, until it is, now, one of national importance, supplying most of our own needs and, though to a comparatively small extent, those of other countries, as in the case of slate, the exports of which are worthy of remark.

DISTRIBUTION.

The rocks from which we obtain our stone for building and other purposes have been formed in a variety of ways. The crystalline silicious rocks, which include the granites and allied rocks, have originated either from melted matter thrown out of the interior of the earth, or from sediments of a silicious nature which, to a greater or less extent, have undergone metamorphism.

The calcareous rocks have resulted from the hardening of the calcareous mud, produced by the breaking up of the shells of marine animals. They have also resulted, to some extent, from the deposition of calcareous matter from solution in water charged with carbonic acid gas.

The sandstones and clay slates, constituting the fragmental rocks, have been formed from the aggregation of particles of older rocks upon the beds of bodies of water, and have subsequently hardened into stone. The various varieties of sandstone are made up almost entirely of quartz granules cemented by materials of several kinds. While quartz granules are very much more common in sandstones than fragments of any other material, other minerals, such



Value of Granite Produced in the Various States during the Year 1894. (In millions of dollars.)

as feldspar and mica, are sometimes found. The nature of the cementing material in a sandstone is an all-important feature, and the sandstones are classed as argillaceous, calcareous, ferruginous, or silicious, according to the particular cement present. Some sandstones contain very little, if any, cementing material, the quartz particles being held together simply by strong pressure. This is the case with the celebrated Berea grit, of Berea, O.

The bluestone quarried abundantly in New York, New Jersey and Pennsylvania, owes its great hardness and durability to the fact that it consists of particles of silica cemented by silica, forming a stone very difficult to work, but well adapted for the purposes of paving and flagging, to which it is chiefly devoted.

Marble has been produced by the combined action of heat and pressure upon ordinary limestone, so that the latter, under these influences, has become crystalline.

Our roofing slate has also been the result of heat and pressure upon a silicious clay, which has thus become hardened, yielding a material having the property of splitting into thin sheets, and thus of rendering it applicable for roofing and for a very long and increasing list of other uses.

In considering the subject of the distribution of stone in the United States, we should expect to find those kinds which have been the result of metamorphism in those regions which have furnished the conditions of heat and high pressure. These conditions are incident to the process of mountain-making. Hence it is that we look for and, with a few exceptions, find the metamorphic rocks, namely, the granites, marbles and roofing slates, in the Appalachian, or the Rocky Mountain systems. The chart on the screen before you shows the values of the granite produced in the leading States during the year 1894. It is evident that most of the States thereon enumerated are traversed by either the Appalachian or the Rocky Mountain systems. The productive States, constituting the eastern section, have yielded 92·17 per cent. of the entire output. This section includes Maine, Massachusetts, Vermont, New Hampshire, Connec-

ticut, Rhode Island, New York, New Jersey, Delaware, Pennsylvania, Maryland, Virginia, North and South Carolina and Georgia. The middle section includes Missouri, Minnesota, South Dakota, Wisconsin and Arkansas, the product of which amounted to 4·54 per cent. of the whole. The product of the western section, including the remaining States, amounted to 3·29 per cent. Intermediate between the eastern and the middle section is a continuous belt of States, which is totally unproductive of granite. These are: Michigan, Iowa, Illinois, Indiana, Ohio, Kentucky, West Virginia, Tennessee, Mississippi, Alabama and Louisiana. In two or three of these States, however, a future output of granite is not out of the question.

The following table shows the States producing marble:

VALUE OF MARBLE PRODUCTION BY STATES FOR THE YEAR 1894.

STATES.	Value.	STATES.	Value.
California	$13,420	Pennsylvania	$50,000
Georgia	724,385	Tennessee	231,796
Idaho	3,000	Vermont	1,500,399
Maryland	175,000		
New York	501,585	Total	$3,199,585

It is evident, from the States included here, that mountain systems are intimately connected with the formation of marble. It is very evident that Vermont is far in the lead of all States producing marble. New developments in marble production are being made in a number of States. The operations in Pickens County, Ga., are of particular interest, inasmuch as a coarse-grained, but highly crystalline marble, of quite a variety of beautiful colors, is being produced on the large scale, and is used largely for the interior decoration of buildings. It may be seen to good advantage in the Drexel Building in this city. The Georgia marble is exceedingly compact and non-absorptive, and although it would, of course, suffer from the effects of exposure to the atmosphere, it weathers uniformly and would therefore not become defaced. It is to be found, not only in the interior of the Drexel Building, but also on the roof,

and its service in that situation will doubtless be watched with interest.

The texture of the Vermont marble is generally fine-grained and sometimes saccharoidal, though in this respect, it is inferior to the Italian marbles. Its color varies from white to blue through various shades.

The Tennessee marble, so highly prized for purposes of interior decoration, comes, for the greater part, from Knox and Hawkins Counties, in that State, and presents a great variety of color. It takes a very beautiful and lasting polish. The stone is beginning to be used for exterior construction, and some grades appear to give entire satisfaction. Methods of quarrying are still, in many places, in a comparatively crude state, and the industry is in its infancy, with apparently plenty of room for the judicious investment of more capital.

VALUE OF SLATE PRODUCTION IN 1894, BY STATES.

STATES.	ROOFING.		Other Purposes, Value.	Total Value.
	Squares.	Value.		
California	900	$5,850	—	$5,850
Georgia	5,000	22,500	—	22,500
Maine	24,690	123,937	$22,901	146,838
Maryland	39,460	150,568	2,500	153,068
New Jersey	375	1,050	—	1,050
New York	7,955	42,092	2,450	44,542
Pennsylvania	411,550	1,380,430	239,728	1,620,158
Vermont	214,337	455,860	202,307	658,167
Virginia	33,955	118,851	19,300	138,151
Total	738,222	2,301,138	489,186	2,790,324

The table before you shows the States producing slate. A line drawn from Piscataquis County, Me., to Polk County, Ga., and approximately following the coast line, passes through all the important slate-producing localities of the country.

Pennsylvania shows great prominence as a slate-producing State. For roofing purposes, the celebrated Peach Bot-

tom slates, taken from a narrow belt in York County, Pa., and extending into Harford County, Md., cannot be excelled. This slate has been exposed on buildings for twenty-five years without showing any change. The belt is quite narrow, and the dip, in some cases, almost vertical, thus necessitating deep quarries, which are costly to work. At present more quarrying is being done on the Maryland side of the line than in Pennsylvania.

The slate-producing belt in Pennsylvania is divided conveniently into a number of regions, known as the Bangor, the Lehigh, the Northampton hard vein, and the Pen Argyl. The most important is the Bangor, which is entirely in Northampton County.

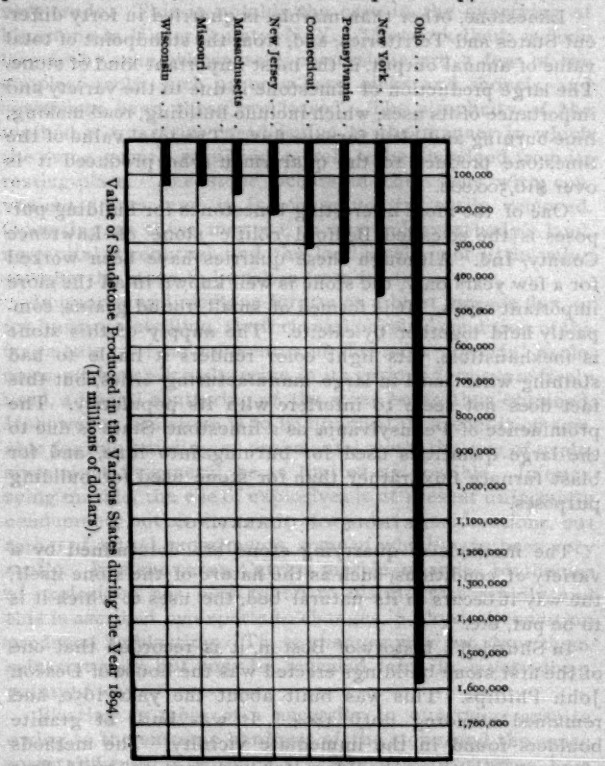
Although red slate occurs in Pennsylvania, the only place in the country at which it was quarried in 1894 was Washington County, N. Y. This, to the best of my knowledge, is the only locality in the world producing red slate, which, on account of its scarcity, brings a high price.

The slate of Vermont presents quite a variety in color, namely, various shades of green and purple. The so-called sea-green slate is produced in comparatively large quantities; it is easily quarried, but commands a low price.

In the production of sandstone, Ohio is seen by the chart to be far in advance of all other States, New York standing second. The prominence of Ohio is due to the vast operations conducted in the deposits of the so-called Berea grit, which is famous for building purposes, and for its value for grindstones and other products used for abrasive purposes. This stone is a fine-grained, very homogeneous sandstone, of a buff or bluish-gray color, evenly bedded. The different layers are quite distinct, and adhere to each other only very slightly. Slabs only 1 or 2 inches thick are used without hesitation, owing to the great strength of the stone.

The absence of cementing material makes the stone particularly well adapted for abrasive purposes, as it has no disposition to glaze, and thus destroy its usefulness. The Berea stone contains iron pyrites, which necessitate careful selection. On long exposure, however, most of this will become yellowish from oxidation of the iron; but this so-

called mellowing with age is claimed as an advantage, and, unless it occurs in blotches, it is no disadvantage. The quarries at Berea, where the most improved appliances are



liberally used, are, perhaps, the most interesting. About 40 acres at Berea have been quarried over, and recently a large addition to the quarry land has been made by the operating company.

The Potsdam sandstone of New York possesses exceptionally fine properties in every way, and stands very high in the opinion of experts.

Limestone, other than marble, is quarried in forty different States and Territories, and, from the standpoint of total value of annual output, is the most important kind of stone. The large production of limestone is due to the variety and importance of its uses, which include building, road-making, lime-burning and blast furnace flux. The total value of the limestone product to the quarrymen who produced it is over $16,500,000.

One of the most interesting limestones for building purposes is the so-called Bedford oölitic stone of Lawrence County, Ind. Although these quarries have been worked for a few years only, the stone is well known in all the more important cities. It is formed of small, round grains, compactly held together by calcite. The supply of this stone is inexhaustible. Its light color renders it liable to bad staining when used in large manufacturing cities, but this fact does not seem to interfere with its popularity. The prominence of Pennsylvania as a limestone State is due to the large quantities used for burning into lime, and for blast furnace flux, rather than for stone used for building purposes.

METHODS OF QUARRYING.

The methods of quarrying stone are determined by a variety of conditions, such as the nature of the stone itself, the way it occurs in its natural bed, the uses to which it is to be put, etc.

In Shurtleff's history of Boston, it is recorded that one of the first stone buildings erected was the house of Deacon John Phillips. This was built about the year 1650, and remained standing until 1864. It was built of granite boulders found in the immediate vicinity. The methods of preparing these boulders for use was to build fires around them, and then to drop heavy iron balls on them from a considerable height, thus breaking them into sufficiently small fragments. This method of quarrying, if it may be so designated, may be regarded as one of the first

to be applied in this country. While vast strides have been made in quarrying since that time, it is true, nevertheless, that some of the methods in use to-day are still very crude. This is notably the case in the quarrying of bluestone in Ulster County, N. Y. The work there is done largely by men whose sole possessions are a few of the simplest tools, such as crow-bars, picks and shovels, and sometimes even these are leased. The simplicity of the method of quarrying used is due to the manner in which the stone occurs, requiring merely to be dislodged from its resting-place. The stone occurs in thin beds with convenient joints, and it is, consequently, easily removed. Operating, as these men do, on any and everybody's land, no capital is required, and the land itself is of little value save for the stone to be taken from it.

In quarrying limestone for use as a blast furnace flux, or for burning into lime, the form and physical condition of the fragments is of no moment, and the most powerful explosives, such as nitro-glycerine in its various forms, are freely used, a liberal shattering of the stone being thus obtained. If, however, the stone is to be quarried in a condition suitable for fine building or ornamental work, the use of explosives must, in general, be as limited as possible. In quarrying marble, the use of explosives is at present universally condemned, not as the result of *a priori* considerations, but rather of actual experiments, some of which have been very costly. In some cases, Carrara marble, quarried by the use of explosives, has been found to disintegrate rapidly, and this is ascribed by experts to changes in physical condition produced by blasting. These changes may not show themselves at once, but may be revealed later in a very disappointing way.

Blasting is more of a necessity in quarrying granite, owing to the extreme hardness of the stone, and the consequent difficulty of working it. The best quarrymen, however, exercise great care and discretion in the use of powder.

A system of blasting, known as the Knox rock-blasting system, has come into quite general use within a few years.

The results obtained are those which were sought for by the method known as Lewising, but the Knox process is safer and quicker, takes less powder, and, for certain kinds of stone, gives sound blocks as the result of the blast, besides leaving a smooth wall-face for future operations. A round hole is first drilled to the required depth, and into this is driven a reamer, which cuts V-shaped grooves, on opposite sides, to the full depth of the hole. A number of such holes are drilled along the line which the fracture is to follow, and in line with the grooves. The charge is then inserted, and the tamping is done so as to have an air-space as great as possible between the tamping and the charge. The explosive has thus the greatest chance to produce expansion, not only from the gases generated, but also from the air present. The explosion, being directed in the line of the grooves, causes very little shattering, and rectangular blocks may be secured without loss of valuable stock.

In the hands of the Cleveland Stone Company, at its Berea quarries, the system appears to be invaluable. It would seem as though one might almost stand on the block to be blasted out without danger, so little spalling is produced. Among granite producers the system does not appear to have made great headway, but at Barre, Vt., one of the firms quarrying there reports uniform success with its use.

Within the past few years a number of noteworthy experiments have been made in blasting granite with very large charges. In 1887, at Granite Bend, Mo., a shaft 35 feet deep, with communicating channels running in several directions at the bottom, was charged with 32,700 pounds of powder; the explosion of this immense charge broke up stone enough to last the firm for fifty years. A similar plan was used at Stone Mountain, near Atlanta, Ga. This mountain seems to be simply one solid mass of granite, covered here and there only with patches of soil. After a very large blast had been fired, earthquake-like rumblings were heard within the mountain for a week or more afterwards, before equilibrium became again established.

My time will permit of a consideration only of the more important details involved in quarrying.

The bedded structure of stratified rocks is of vast importance to the quarryman, since the different beds or layers are easily separated from each other. If these beds are of a convenient thickness, the ease of working is much enhanced, but if they happen to be of great thickness, requiring splitting with wedges, they may not be of great advantage.

If these beds are horizontal, the process of quarrying is much simplified, since the work then consists in cutting vertically down. This is true of a number of sandstone quarries; for example, those at Berea, Ohio. One disadvantage of this, however, is that the quarrymen can tell nothing about what is deeper down. This is not the case where the beds have been tilted up at a considerable angle, since the qualities of stone in different layers can be determined from an examination of the exposed edges of the different beds at the surface of the ground.

At West Rutland, Vt., the marble quarries have the benefit of this condition, but the expense of quarrying is greater, and resembles mining, inasmuch as at a considerable depth tunnelling has to be resorted to.

Not only do the stratified rocks split easily in the stratification planes, but the same is true also of marble, in which the stratification of the original limestone deposit has not been entirely modified by metamorphic action.

In granite no bedding exists, but advantage is taken of fractures, called joints, which permit the rock to be taken out more readily. Different systems of joints intersect each other, thus facilitating the breaking up of blocks in rectangular or other shapes. Block and sheet quarries are those in which joints divide the rock into natural blocks and sheets, of which advantage is taken by the quarryman.

Frequently, in granite quarries, the only machinery used consists of drills and derricks. Channelling machines are used occasionally, and then only in getting out the most valuable stone. The hardness of granite is such as to make the use of these machines too expensive. In marble and

sandstone quarries, channelling machines are freely used. The following illustration will serve to give a fair idea of the channeller.

The channeller, running on a track back and forth, over the quarry floor cuts grooves in the stone 2 inches wide and 4 to 6 feet in depth. Holes are then drilled horizontally by means of so-called gadding machines at the bottom of a block, which is then forced out by means of wedges. These drills work by either steam or compressed air. In the case of the Ingersoll drill they operate by striking blows, while the diamond drill operates by boring. The operation of the latter is very rapid.

The next illustration shows a channeller at work in a marble quarry. In dressing, carving and polishing marble and granite, a number of improvements have recently been made. In carving both granite and marble a number of attempts have been made to discover an instrument or machine which would successfully take the place of the long-used mallet and chisel, which yield results so slowly. Success at last appears to have been, at least partially, if not wholly, attained by the MacCoy pneumatic tool, which was invented a few years ago, and which the Franklin Institute has honored by the award of the John Scott medal. This instrument is actuated, as its name indicates, by air pressure; it is held in the hand and is guided over the tracing to be carved, its pointed or chisel-edged tool striking very rapid blows. Workmen who use it claim that the rapid jarring of the hand becomes very unpleasant, and some of them are decidedly opposed to it on that account. It is employed to some extent in carving granite, but to a much greater extent with marble, with which it is certainly very effective.

In grinding granite, the abrasive material now almost exclusively used is either chilled-iron globules, steel emery, or crushed steel. A coarse grade is needed at first, then a finer kind, and lastly fine emery. Final polishing is done in much the same way as grinding, except that a felt-covered disc is used instead of an iron one, and putty powder mixed with a little water instead of coarse grinding materials.

Granite for columns, baluster-posts and urns, is now generally turned on lathes, some of which take a shaft of granite 25 feet long and 5 feet in diameter. The granite is cut away by the wedge-like action of a steel disc, set at quite an angle with the stone, and running on an automatic carriage. The discs are revolved by the pressure of the stone as it slowly turns in the lathes.

The scientific examination of rocks, for the purpose of determining their structure, is an exceedingly important process, in connection with the question of determining the applicability of the material to various economic uses. It is not long since the science of petrology, in its development, was limited to the simplest methods of acquiring knowledge of the intimate structure of rocks. These methods involved the use of a pocket lens, chemical analysis, and determinations of hardness, specific gravity and the like. Chemical analysis of the mineral aggregations constituting rocks is, of course, desirable; but, in many cases, the results of such analysis, if conducted on the rock as a whole, and not upon separate constituents, are of comparatively little value. For, while analysis may tell correctly the composition of the rock as a whole, it may tell nothing of the constituent minerals, their physical condition, or the manner in which they are held together. The hardness of a stone, from the economic standpoint, is a very different thing from the hardness of its constituent minerals. These minerals may be quite hard themselves, and yet, if not firmly held together in a rock, the latter may, as a whole, be quite soft.

Specific gravity determinations are of value, since the strength and absorptive properties of a stone depend upon the density. The more dense the stone, usually, the stronger it is, and the less absorptive of moisture.

The introduction of the microscope into the study of the structure of rocks occurred about the year 1867, although the method of grinding rocks into thin sections was used as early as 1831, for the purpose of studying microscopically the minute internal structure of fossil plants. The advantages of a microscopical study of rocks are very apparent at the present day, not only to petrology as a science, but also

in its bearing on questions concerning the applicability of stone for building and other purposes.

For the purpose of illustrating the use of the microscope and polariser in examining sections of rock, I have a few specimens which I submit for your inspection.

The methods of testing stone for building are at present not satisfactory; but doubtless, in course of time, microscopical examination and other means will add much that is desirable. Very little is done to determine the conduct of the stone under the influence of fire, frost, weathering, and the sudden cooling from an intensely heated condition, to which stone is frequently subjected during a conflagration, by flooding with water from fire engines. The principal test to which stones are at present subjected is that of compressive strength. The value of such a test is either overestimated or not sufficiently well understood, as a rule. A freshly quarried stone will almost invariably stand vastly more pressure than it will be called upon to bear. It is of more value to know what a stone will bear after many seasons of exposure to heat, frost and moisture.

A knowledge of the porosity of a stone is of importance, since the more porous it is, the more water it can absorb, and hence, the more liable it will be to disintegrate under the expansive action of water in freezing. It is the opinion of high authorities to-day that no test of stone is equal to an examination of natural outcrops, or of buildings of long standing, of which it forms a part.

NOTE.—For the historical data in this lecture I am indebted to George P. Merrill's work on "Building and Ornamental Stone." The reports of the Tenth and Eleventh Censuses have also been used.

THE MODERN OFFICE BUILDING.[1]

BY BARR FERREE.

A lecture delivered before the Franklin Institute, November 15, 1895.

[*Concluded from vol. cxli, p. 71.*]

The utmost diversity exists in the structure and the detail of the supporting frame in the skeleton construction. This variety is dependent, in a measure, upon the special conditions arising in each building; but it is largely due to the individual preferences of the designing engineer. No extended series of tests have ever been made as to the relative merits of the various columns, girders and beams employed in modern work, though special tests have been made in some particular instances. Nothing in the way of comparative tests has, however, been made.[45] As a matter of fact, therefore, the use of certain forms depends more on the preference of the engineer and the adaptability of special shapes, than upon an absolute knowledge of their intrinsic merits.

Although the details of the construction frequently differ widely in buildings employing the same structural methods, certain general principles underlie the selection of the section of the columns. These principles have been well elu-

[1] In undertaking to treat so large a subject as the modern office building in all its phases, economic, structural and æsthetic, within the scope of a single article, it is obvious that only the most summary review can be attempted. In order that the reader, who may be desirous of pursuing the subject further, may at once place his hand upon the latest literature on the subject, references have been made, in the foot-notes, to recent articles and papers in the professional journals, in which fuller accounts of the points under discussion may be found. The foot-notes appended to this paper are not, therefore, offered as authorities for the statements contained in it, but as keys to more extended studies of the subjects. The references are not, in any case, to be taken in a bibliographic sense, nor is any pretence made to do more than cover the latest American literature in a most summary fashion.

[45] An exhaustive series of tests, largely through the generosity of the Carnegie Steel Company and the Continental Iron Works, are about to be undertaken by a committee of engineers and architects.

cidated by Mr. C. T. Purdy, who has designed the steel frames of many of the notable buildings of Chicago. According to this authority, the advantages, to be considered in a building column are: (1) cost and availability; (2) shop-work and workmanship of column; (3) ability to transfer loads to center of column; eccentric loading; (4) convenient connections of floor systems; (5) relation of size of section to small columns; (6) fireproofing capabilities of the section.[46]

Many sorts of structural columns are upon the market, each having its supporters and its particular advantages. The conditions under which these columns are used are so exacting and so varied, that of none of them can it be said that it is *the* column to use in all circumstances. Local conditions and cost and availability are more likely to determine the selection of a particular column, especially of a type that has long been in use, rather than some of the newer types, whose advantages may be offset by an increased cost, or, if it is a patented column, by the difficulty of securing it when wanted. In the following table the commoner sorts of columns are named and classified by the number of rows of rivets each requires.

One row: Larimer column.

Two rows: Z-bar column without covers.

Four rows: channel column with plates or latticed; 4-section Phœnix column; Gray column; Keystone octagonal column.

Six rows: Z-bar column with single covers.

Eight rows: box column of plates and angles; latticed angle column; 8-section Phoenix column.

Ten rows: Z-bar column with double covers.

In addition to these shapes, compound or complex columns are used under special circumstances. Special forms of the standard types have also been introduced to meet special requirements.

All these columns are now made in wrought steel. Prior

[46] C. T. Purdy: "The Steel Skeleton Type of High Building," *Engineering News*, December 5, 1891, *seq.*

to the introduction of this material into building operations, columns of cast iron were employed. These are still frequently used, but modern engineering practice does not encourage it. While this material has some advantages, it is very uncertain, and its liability to fracture renders it dangerous to use.[47]

Although the particular section of the column in high buildings is without influence upon the design, some representative buildings are grouped below as illustrative of recent methods.

Cast Columns.—Chicago: Manhattan, Leiter, Tacoma, Auditorium, the Rookery, Phenix, Owings, Unity—all relatively early high office buildings.

Z-Bar Columns.—Chicago: The Fair, Y. M. C. A., Isabella, Pontiac, Caxton, Venetian, new Monadnock (skeleton part), Champlain, Marquette, Stock Exchange, old Monadnock, Great Northern Hotel, Woman's Temple, Ashland Block, Marshall Field, Rand-McNally, Boyce, Hartford, Columbus Memorial, Atwood; Pittsburg: Carnegie.

Z-Bar and Phœnix Columns.—Chicago: Old Colony (special shapes), Schiller Theatre.

Box Columns of Plates and Angles.—Chicago: New York Life.

Channels and Plates.—Chicago: Fort Dearborn (lower floors of plate and angles, then channels and plates; upper stories of latticed channels).

Plates and Angles.—Chicago: Masonic Temple, Teutonic.

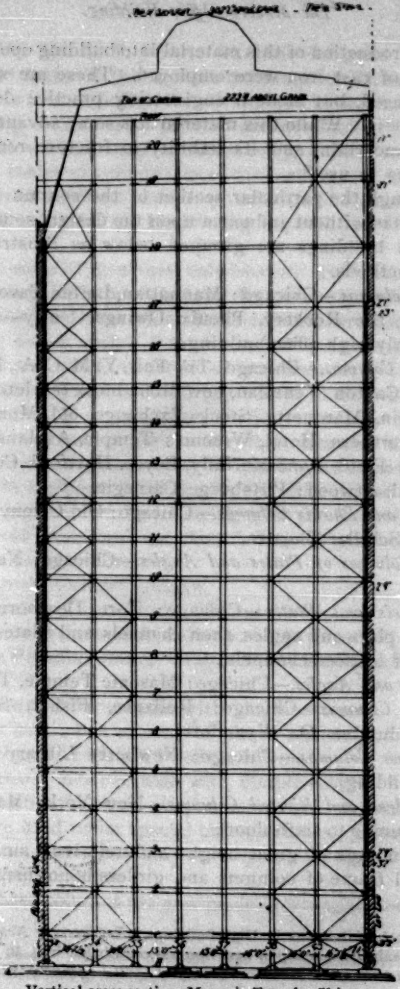
Gray Columns.—Chicago: Reliance, Fisher, Steinway Hall; Columbus, O.: Wyandotte.

Larimer Columns.—Chicago: Newberry Library (not an office building).

Cast Iron and Riveted Columns.—New York: Manhattan (cast columns to sixth floor).

In buildings of great height and relatively small area, the steel frame of columns and girders is not usually con-

[47] "Cast Iron Columns in High Buildings," *Engineering News*, May 24, 1894. An exhaustive study of cast iron was contributed by J. B. Johnson to the *Transactions of the American Society of Civil Engineers*, **22**, 91.



Vertical cross-section, Masonic Temple, Chicago.

sidered sufficient to resist the force of wind pressure.[48] The frame is, therefore, often braced, though in low buildings, and in high ones of large lateral dimensions, it is frequently omitted. The Masonic Temple, Chicago, of twenty-one stories, 273 feet high and 19,224 square feet area, is provided with a system of rod-bracing inserted at each side of the elevators. The Stock Exchange, of the same city, on the other hand, of thirteen stories, 173 feet high and with a floor area of 18,000 square feet, has no wind bracing whatever. As in every department of the mechanics of high building, engineering practice differs greatly on this point, and much difference exists, not only as to the methods of resisting the wind forces, but even as to their amount and application.

Four general methods are in ordinary use, though the details of application frequently differ. These are: (1) sway-rods, or diagonal braces, connecting the columns diagonally between single floors; (2) the same, running through two stories, cutting the intermediate girder at the center of the diagonals (both systems are used in the Masonic Temple, Chicago, the sway-rods being connected with I-beams between the columns and below the floor system[49]); (3) portal arches (Old Colony Building, Chicago[50]); and (4) knee-braces, not an advantageous form (Isabella Building, Chicago; also, in a modified form, in the Fort Dearborn Building). The steel frame is sometimes braced by making the joints of the columns, usually in two-story sections, break at alternate stories (new Havemeyer Building, New York). The value of this method is, however, problematical. The selection of the type of wind bracing will depend, to a very considerable extent, upon the openings of the building, the location of the doors, partitions, and the like.

[48] W. H. Bixby: "Wind Pressure in Engineering Construction." Appendix C, of the Report of September 29, 1894, of the Special Army Engineer Board, as to the Maximum Span Practical for Suspension Bridges. Reprinted in *Engineering News*, March 14, 1895. H. H. Quimby: "Wind Pressure in High Buildings," *Transactions of the American Society of Civil Engineers*, **27**, 221. G. B. Waite: "Wind Bracing in High Buildings," *ibid.*, **33**, 190.

[49] *Engineering Record*, January 21, 1893.

[50] *Engineering News*, December 21, 1893.

The skeleton frame is, by its construction, a well-braced structure. It is not remarkable, therefore, that only the slightest vibration and deviation from the perpendicular have been noted in the best-built office buildings, even the highest. Some very careful observations made in the Monadnock Block, Chicago, showed a very slight vibration in heavy wind-storms.

The construction of the floors of office buildings, including the size and dimensions of the girders, their connection with the columns, the filling-in of the spaces between the girders and beams, and the laying of the floors, require as much care and forethought as the erection of the columns. In designing floors, the engineer has to consider the dead loads, or permanent weights of the building, and the live loads, or movable weights.[51] These factors are treated in the building laws of our leading cities, and the scientific phases of the loading of beams have been carefully studied and the results tabulated in many engineering publications.

The stability of the frame, as well as of the floor itself, depends largely upon the advantages for good connections provided by the section of the column; and this, as before remarked, is one of the important considerations that must be taken into account in determining the class of column to be used.

Although the utmost diversity exists in the manner of filling-in the spaces between the beams of the floor, arches of fire-clay are now almost universally used.[52] They are fireproof, waterproof, have a flat upper and lower surface, are lighter than the solid brick arch, are free from shrinkage, can be made of any depth, and may be used for large and

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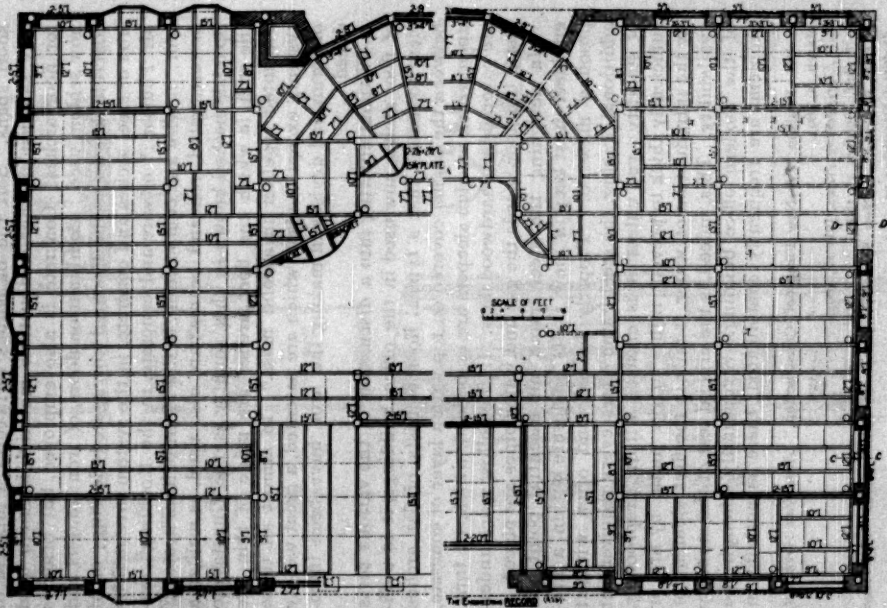
[51] Jenney and Mundie: "Live Loads and Supports in Office Buildings" (New York Life, Chicago); *American Architect*, Feb. 10, 1894; also March 10, 1894; C. H. Blackall: "Live Loads in Office Buildings," *American Architect*, August 26, 1893.

[52] A summary of the more notable tests made on fireproof flooring will be found in the series, "Fireproof Floor Arches," by George Hill, *Brickbuilder*, January, 1895, *seq.* G. Hill: "Tests of Fire proof Flooring Material," *Transactions of the American Society of Civil Engineers*, **34**, 493. "Bericht des Gewölbe-Ausschusses." Sonderabdruck aus der Zeitschrift des Oesterr.-Ingenieur- und Architekten-Vereins, Wien, 1895.



Beam plans and details of framing, Masonic Temple, Chicago. Half plan of second floor to left; Half plan of fourth floor to right.

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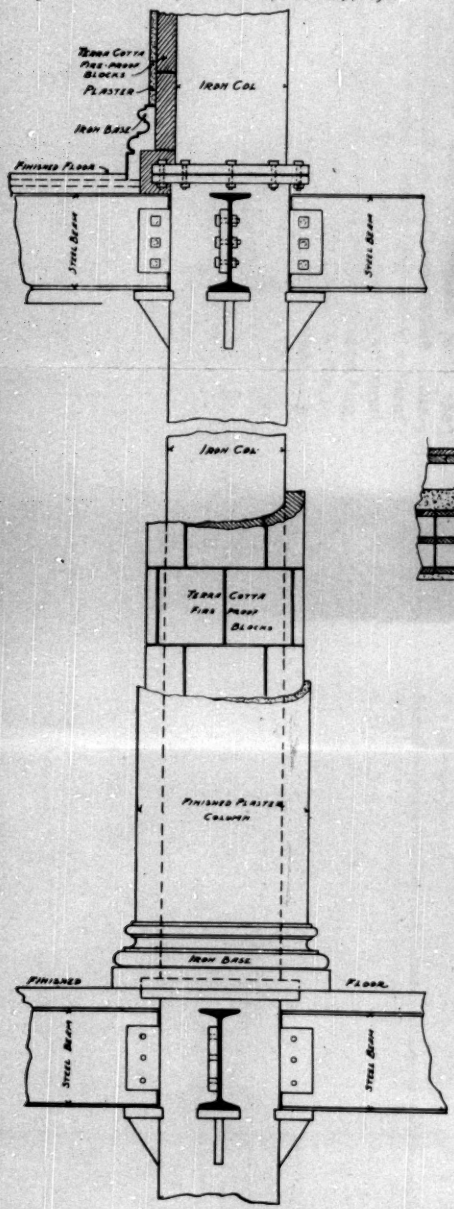
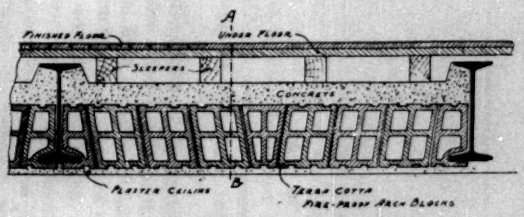
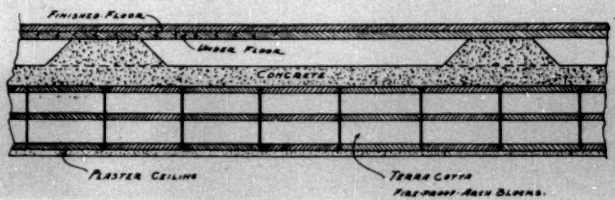




TRANSVERSE SECTION



LONGITUDINAL SECTION A-B

NEW YORK COMMERCIAL BUILDINGS.

EAST WASHINGTON PLACE BROADWAY WAVERLY PLACE MERCER ST. N.Y.

DETAILS OF CONSTRUCTION

ROBERT MAYNICKE
ARCHITECT
111 FIFTH AVE. N.Y.

short spans. Soft tile or porous terra-cotta, a mixture of clay, sawdust or other combustible material, is much used for floor arches. Concrete is also employed, but brick is now seldom used. Combination floors, of iron troughs and concrete, known as the Pencoyd corrugated flooring; or of iron or steel arches and concrete, in the system invented by Mr. Poulson;[53] or wire and concrete, in the Roebling[54] system; or wire and composition, in the Metropolitan system;[55] or corrugated iron and beams[56] are also used, as well as a Spanish method known in this country as the Guastavino tile arch, in which the floor arches are made of thin tile cemented together in a solid mass.[57] In almost all these systems, except the last, which are patented, a great variety of forms and devices in making the arch have been introduced.

Without entering into a discussion of the various sorts of floor arches now used in the office buildings, it is sufficient to remark that a typical floor consists of flat arches between the beams, covered on top with a layer of concrete, upon which wooden sleepers are embedded, which, in turn, are covered by a hardwood floor. In the hollow space underneath the floor-boards the gas and water pipes are placed.

In designing the steel frame, an essential point the engineer must keep in view is its enclosure within a fireproofing material. Properly braced, and often without additional bracing, the steel frame offers every requirement of stability; yet, unless it is encased within fireproofing, sufficiently thick to prevent injury to the metal by fire, or by the introduction of water, it fails in the first element of availability. This, indeed, is the crucial test of the stability of the modern office building. Structurally, though the problems are frequently complicated, there is nothing in

[53] N. Poulson: "A New Fireproof Construction," *American Architect*, March 25, 1893.

[54] *Engineering News*, July 18, 1895.

[55] *Ibid.*, October 25, 1894.

[56] H. B. Seely: "A New System of Fireproof Construction," *American Architect*, December 15, 1894.

[57] R. Guastavino: "Cohesive Construction," *American Architect*, August 26, 1893; *Inland Architect*, May, 1893.

any part of the work that modern engineering practice is not thoroughly competent to handle. It has not, however, yet been demonstrated how long these buildings will endure.[58] It is true the skeleton system has been used too short a time to enable any practical experience to throw any light on this point; but it is strange that no attempt has been made to examine the state of the metal in the older buildings of this type.

The question is of more moment since the modern office building is a structure whose period of existence is intended to far outlast that of the buildings it replaces. The amounts now invested in them are so large that nothing short of an almost permanent duration can render them profitable.

So far as present experience goes, the modern office building has amply satisfied all the claims made for it, when the construction has been good and thorough, and of the most approved type. It has been demonstrated several times (fires in Temple Court,[59] Edison and World Buildings, New York; Athletic Club,[60] Schiller Theatre,[61] Chicago,) that fires originating in one place can be confined to the room in which they occur, or, at the furthest, to the adjacent apartments. It has been shown, also, that, even where the fire has been a severe one, as in the Chicago Athletic Club, the structure of the building can escape without serious damage.[62] On the other hand, early and imperfect methods of fireproofing, as in the Manhattan Savings Bank, New York, are almost as unsatisfactory and as useless as no fireproofing at all.

The most zealous opponents to the high buildings are fire departments. It is doubtless true that the fire departments of all our great cities would be unable to cope

[58] C. H. Blackall: "The Endurance of Structural Metal Work;" *Brickbuilder*, November, 1894.

[59] *Engineering News*, April 6, 1893.

[60] *Ibid.*, November 24, December 1, 1892; January 12, 1893; *Inland Architect*, December, 1892.

[61] *American Architect*, April 28, 1894.

[62] "A Practical Test of Fireproofing," (Lumber Exchange, Minneapolis), *Inland Architect*, August, 1891; C. H. Bebb: "Fire Losses in Fireproof Buildings," *Engineering Magazine*, February, 1893.

with a destructive fire in a very high building, owing to the lack of water pressure and the absence of special apparatus designed for use in such emergencies. On the other hand, the necessity of protecting these buildings against such dangers has certainly resulted in very considerable improvements in their erection, which have been manifested, not only in high buildings themselves, but in less costly structures. There can be no question at all but that the average of fire-resisting qualities in our modern cities has been greatly increased since the introduction of the skeleton system of construction, just as it is equally certain that these buildings are the safest structures we have, in any sense. This fact is generally overlooked by the fire chiefs in their criticisms on these buildings, and by popular critics who are not always disposed to accept them at their true worth.

The danger the office building is most subject to is not from within, but from without; that is to say, from the older and smaller buildings immediately surrounding it, or what is called the "exposure risks." There can be no question at all but that the safety of our cities is greatly increased by the continued erection of modern office buildings.[63]

Part III.

The design of the office building falls naturally into two great divisions: the structure and the architectural form. The former belongs to the engineer, the latter to the architect. The engineer has a necessary part in the design of the office building, inasmuch as his services are essential for the making of the foundations and the erection of the steel skeleton. To him belongs, also, the preparation of the frame for the coating of stone, or of brick or terra-cotta,

[63] Edward Atkinson: "Fire Risks on Tall Office Buildings," *Engineering Magazine*, May, 1892; J. M. Carrère: "Interior Fireproof Construction," *ibid.*, October, 1892; T. M. Clark: "Skeleton Construction and the Fire Department," *American Architect*, October 20, 1894; P. B. Wright: "Fireproof Construction and the Practice of American Architects," *American Architect*, August 19, 1893; "The Reduction in Cost of Fireproof Construction," *Engineering News*, May 10, 1894.

and similar mechanical matters. These problems are so complicated and varied as to require the services of a specialist.

But because the engineer is rightly employed for the engineering of the high building, it must not be supposed that the architect may be ignorant of his duties or independent of his work. Every structural detail must be studied and understood by the architect. The relations of the two are co-ordinate, and each must know the other's province, and keep the other's purpose in view as well as his own.

That this is not always so, the history of modern office buildings often too clearly shows. It is not unusual for an architect to prepare his design on his drawing-board, and then send for an engineer to arrange its construction for him. On the other hand, it would be easy to point out designs apparently made by an engineer, and certainly carried out without the supervision of an educated architect. That there is more or less friction between the architect and the engineer; that the architect looks upon the engineer as too "practical," the engineer upon the architect as too visionary, is a fact not to be denied by those who have watched the development of the two professions. Only by the warmest sympathy and constant co-operation can the design of an office building be carried out in a proper spirit and with satisfactory results.

The exterior of a building is generally the criterion by which its success is measured. It is unreasonable that this should be so, for few structures—and especially few modern structures—are built for external show. But the office buildings have so little to offer within, in the way of ornament or of art, that the general public, and perhaps the architectural public, have fallen into the habit of judging them by their façades. A not unnatural consequence has been that a finely designed office building has now a greater commercial value than one that is badly designed; a good-looking building is thought more of than an ill-looking structure; and so the façade has a monetary value in these buildings which it does not always have in other structures.

From the commercial side of the question, it is quite as necessary to develop the artistic aspects of the high buildings as the structural. And, certainly, it is a monstrous architectural sin to put up buildings whose single merit shall be their size, and whose chief distinction shall be their hideousness. It is true we have many buildings, distributed throughout the cities of our land, of which no more can be said; but, with a wider appreciation of the value of æsthetics in commercial buildings, there must come a change for the better. Those that have been built must needs remain where they are; but those that are to come must, inevitably, show a betterment in design, as they will, unquestionably, show a betterment in construction.[64]

The structure of a building lies at the basis of its design. This is a fundamental fact in architectural æsthetics. Now, in a sense, the modern office building does not show its structure, either within or without; the steel columns and girders and beams whereon it is carried are covered up by the exterior surfacing or by the fireproofing or coating within. It is impossible to tell a solid wall from one built on the skeleton principle, and the structure of a hybrid or complex wall is equally invisible. How, then, it may be asked, can we have a successful high design, if, at the outset, a fundamental principle of design is ignored? This question has been asked many times, and architects have learnedly discussed this point without, it must be admitted, throwing much light on it.[65] But the question need not be asked in this way. The structure is, indeed, the basis of the design in the high building, as in the low one; but this does not call for the unveiling of the metal skeleton, nor for a frank display of the material of the structure. The *structure* may be shown, but the *materials* are necessarily hidden.[66]

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[64] Barr Ferree: "The High Building and Its Art," *Scribner's Magazine*, March, 1894.

[65] Thomas Hastings: "High Buildings and Good Architecture," *American Architect*, November 17, 1894.

[66] Barr Ferree: "Structure and Material in High Design," *Brickbuilder*, March, 1894.

For it is admitted on all hands that steel and iron are impossible materials for high structures unless they be covered with a fireproof material. That, indeed, is one condition of their serviceableness. A naked steel column would be a source of constant danger. It would suffer deterioration from dampness and from contact with the atmosphere, and a fire would be fatal to its stability. A high building of any sort, in which the steel lines of the columns and girders would form a feature of the external design, would be too dangerous to warrant erection. We cannot, then, show the material of our building in the design, though we may, in a sense, show its structure.

Not only are there structural reasons prohibiting the direct employment of the metal frame as a basis in the design of high buildings, but those structures in which the architectural framework has been reduced to the smallest limit, so that the building is little more than a skeleton of brick or terra-cotta, show how unsatisfactory such a treatment is æsthetically. The Reliance Building, in Chicago, is, perhaps, the most notable attempt yet made to reduce the amount of the enclosing material to a minimum, and the design is scarcely more than a huge house of glass divided by horizontal and vertical lines of white enamelled brick. The Fisher Building, in the same city, and the Mabley Building, in Detroit, are other examples illustrating the same tendency, though in not quite so pronounced a fashion as in the first instance. It is a good principle in architecture that a building should not only be firm and strong, but that it should seem so. This reasonable requirement is not fulfilled in these designs. A high office building requires an appearance of being built solidly to produce the best effect, or, indeed, to produce an architectural effect. This, however, does not excuse the exaggerated effect of heaviness and stability that may be seen in some designs, and which is quite as bad as extreme tenuity. Perfect naturalness of expression, good taste and an understanding of the structural requirements of the problem are all the architect needs in designing his façades.

A few years ago 10 or 12 stories were considered

formidable attitudes for office buildings; to-day 17, 18, 20 and even more stories are talked of and built as a matter of fact and as scarcely out of the ordinary run. And not only are these buildings high, but they are relatively narrow. This is true more particularly of New York than of Philadelphia or Chicago, in both of which cities, and especially in Chicago, many of the large office buildings are on sites of generous size, to the great dignity of the design, and to the very considerable lessening of the difficulties of the architect. In New York the custom of selling land in lots of 25 feet by 100 has given many of the office buildings an especially unhappy dimension in width, which has rendered a pleasing design a matter of much difficulty for the architect, and which has, in many cases, caused many disastrous results. New York has no such monumental office buildings as the Masonic Temple, the Woman's Temple, the Auditorium, the Schiller Theatre, the Monadnock Block, the Marquette and Old Colony Buildings, and many others in Chicago.

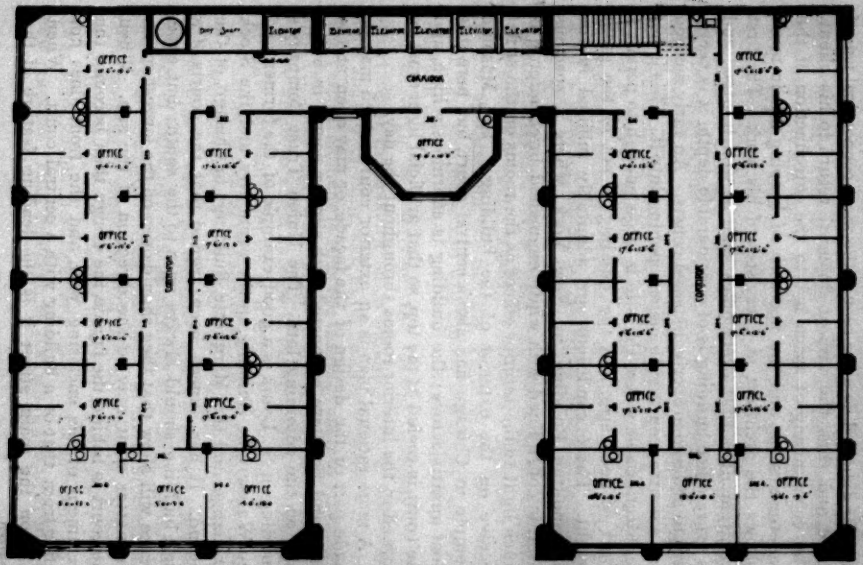
The height is, therefore, the leading element in the structure of the modern office building. Each additional floor adds to its value, and to its natural upward tendency. The vertical element is thus the leading factor in its design, and the architect who most successfully employs this feature achieves a real success in the handling of this very difficult problem; for it is a difficult problem to solve. The historic styles, save the Gothic, are concerned with low or horizontal designs. History and precedent offer little to the designer of the high building, which is at once the most modern of buildings, and an entirely new thing under the sun in architecture. And although modern architecture offers nothing in sequence with the older architecture, save in point of time, it is a task of no small magnitude to break away wholly from tradition and design in a new way for a new purpose. This, however, is just what the architect of the high building has to do, and the speedier this is admitted, the better it will be for the appearance of our streets and the progress of our architecture.

The first problem the architect has to study in his design

is the plan. His site must be advantageously used, and his interior disposed so as to secure the most economical use of space, and thus the utmost financial return to his client. The economising of space led to the introduction of the skeleton system, and the necessity of keeping this in mind follows the architect at every step of his work. The first requirement is that every office shall be well lighted; and as every office building is of considerable depth, it is necessary to arrange properly disposed courts. An early method was a central court, with offices opening into it. This is not unobjectionable where the site is large enough to permit a court of good size, and the building is not of too great height. These conditions are admirably fulfilled in the Metropolitan Building in New York, where a spacious interior court, lined with white enamelled brick, affords as much light to the interior offices as the rooms on the street receive on the exterior of the building. The Masonic Temple in Chicago has also a central court, but here it is most unsatisfactory; the building is enormously high, and the court is roofed at the top, so that artificial light must be burned in the interior rooms throughout the day.

A more rational plan is an exterior court, which may be made part of the design of the façade, or may open at the back, and be there connected with similar courts in buildings on the adjoining lots. The Union Trust Company's Building in St. Louis is a good example of the former, and the Wainwright Building, in the same city, and the Stock Exchange and the Marquette Buildings in Chicago, of the second. It has, indeed, been argued that the courts of a hign building should always open to the south; but experience will show that they should open on the largest space, no matter what may be the direction of the sun. When the court is behind the façade the design then becomes the treatment of the enclosing wall, and the front does not differ from that of a building with a central court. When it is on the main street it is the leading feature of the design.

The disposition of the courts settled, the arrangement of the offices, the location of the elevators, the size and position

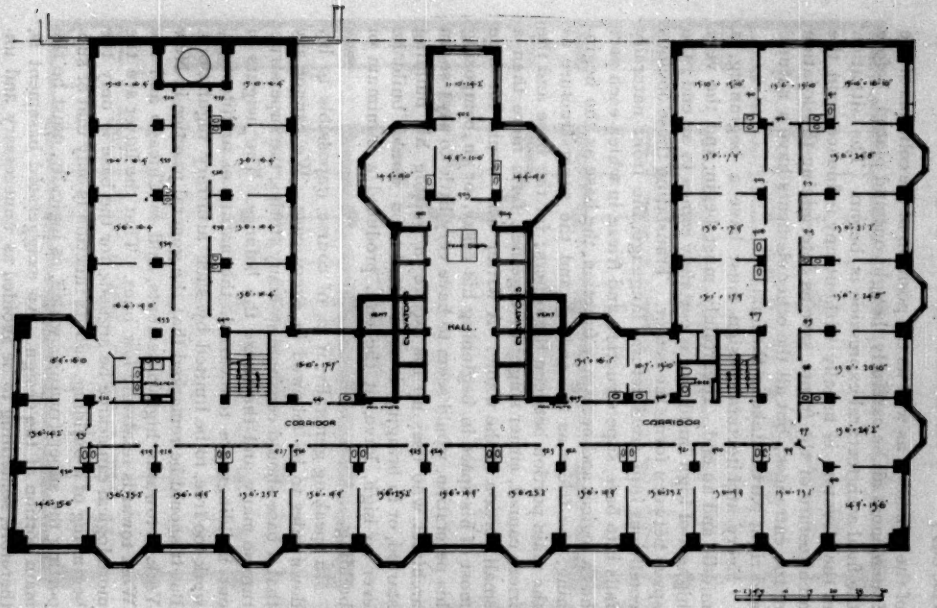


Typical floor plan, Union Trust Building, St. Louis.

of the windows, as well as the position of the columns of the frame, must all be carefully thought out and placed, before the final architectural expression is begun. The situation of the elevators is usually without any influence upon the architecture of the fronts, save as determining the location of the entrances; but all the other elements have a natural and right part to take in the final task.

Every architectural design must have a beginning, a middle and an end. It certainly must begin, and the very highest of high buildings as certainly comes to an end; the space between forms the center. Translating these obvious conditions into architectural language, the front naturally falls into base, superstructure and frieze, in which each part has a logical and necessary function, the base as the beginning, the frieze as the ending, and the superstructure as the main portion between the others; for the base and the frieze cannot, either singly or together, form more than a small portion of the whole. A writer who would consume most of his space in beginning his essay, or in composing his peroration, would seem to have very little to say; so an architect who uses up his façade in getting his building started, or in bringing it to a conclusion would, build he ever so high, have, at the end, produced a minimum of building.

In speaking generally, it is, of course, impossible to lay down rules to be followed in every case. We cannot say that a base should consume so many stories, the superstructure so many and the frieze the balance. The heights of our buildings are too varied, the nature of architectural work too free, to be limited by such arbitrary regulations. But it should be remarked that the general practice in New York is towards high basements, and in Chicago and the West towards relatively low ones. That the latter are the more logical can scarce be argued; for the base is only the beginning of a building, and its function is only that of supporting the superstructure, which, as logically, must be the main portion of the design. An exaggerated basement is, therefore, something to be avoided as unnecessary and unwise. Nor does the frieze need to be stretched out over the



Typical floor plan, Stock Exchange Building, Chicago.

upper part. If practice shows, as it does in many buildings, that the uppermost story is needed for mechanical purposes, and is filled with tanks, piping and apparatus used in heating, lighting and ventilating, this difference of function may be naturally shown in the frieze, whose difference in design not only expresses this fact, but serves, at the same time, as the crown and finish of the building.

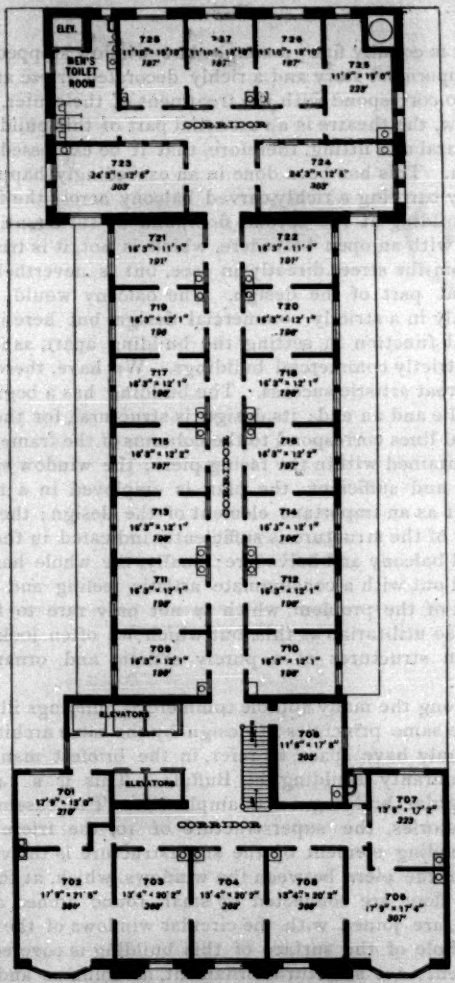
We have, therefore, three great divisions in a high design, each having a function of its own to express, and each having a logical meaning. But these three parts must form a unit. An office building is not a collection of various things put together in a single structure—though many of them offer a most singular diversity of parts—but it is a unit. The basement must be related to the superstructure, and the superstructure to the frieze, and each, in turn, to each other part. The high building must, moreover, be stately and dignified—majestic if it can be, as all great objects are in nature. This effect, which is surely the chief one to be sought in the design of these structures, cannot be obtained through variety, or by cutting up the front into as many parts as possible, only to be arranged and fastened together by means of an internal skeleton of steel. But just as every part of the frame has a meaning, so must every part of the façade. The structure of the office building is an orderly creation, and its architectural or ornamental features must not violate this fundamental law.

Such is the basis on which all good high design must be constructed. Dignity, unity, sobriety, strength, truth; an expression of parts, an indication of function, a simple, straight forward use of materials employed in the telling of a simple story. We cannot, in our façades, show the number of offices housed within, any more than we can show the diversified interests that make the building their home; but we can at least keep within the bounds of reason, and proceed with our architectural part as deliberately, as soberly, and as logically as we proceed with the structure of our frame. This, indeed, must be admitted and understood by the architect, or his design will be marred by those misunderstandings that have already fatally injured the beauty of many high office buildings.

The Schiller Theatre in Chicago is a building 80 feet wide and 17 stories high; the depth of the lot is 180 feet. The theatre is on the first floor at the back, the front of the building, and all the upper part over the theatre, being given up to offices. It might as well be called an office building in which the theatre uses part of the space, as a theatre associated with offices. The union of the two buildings in a single structure is an excellent arrangement commercially, since the theatre can occupy a costly site in the heart of the business center of the city, and the owners derive a handsome income from the offices. The same idea lies at the basis of the design of the Auditorium in Chicago, which is a vast opera house surrounded by a business block and hotel, the income from the latter portions being applied to make up any deficiency in the expenses of the former.

The site of the Schiller Theatre being a long rectangle, with the shorter side facing the street, the architects solved the question of courts by narrowing the building at the sides in the center. The theatre fills all the space, except for a line of offices on the street front, up to the fifth floor. At the sixth floor the side walls are dropped in the center, and windows inserted to light the offices on each side of the corridor in the middle of the building. At the back the *scène* runs up above the ceiling of the theatre, but with the seventh floor the whole of the space is given up to offices, front, back and sides, the plan resembling a gigantic **I**. At the ninth floor the front is stopped on each side, to permit free access of light to the side courts within, the main portion being continued to the seventeenth floor, and given the architectural form of a tower.

The treatment of the front is masterly, and has, perhaps, never been surpassed in high design for simplicity and directness of expression, at once structural and beautiful. The tower in the center is divided into three great bays, finished with round arches at the top, and enclosing spacious and plain windows. At the top is a frieze story of small, round, arched windows, in a rich frame of foliated ornament, that is continued on the broad, boldly projecting cornice which completes the design. The treatment of the



Plan of seventh floor, Schiller Theatre, Chicago.

wings is equally fine; a simple bow window stopped below the uppermost story and a richly decorated frieze and cornice to correspond with the treatment of the center.

Now, the theatre is an essential part of this building; it is natural and fitting, therefore, that it be expressed in the design. This has been done in an exceedingly happy manner, by carrying a richly-carved balcony across the front of the building at the second floor, and by surmounting the tower with an open belvedere, which is not, it is true, visible from the street directly in face, but is nevertheless an integral part of the design. The balcony would be an anomaly in a strictly commercial design, but here it has a natural function in setting the building apart, as it were, from strictly commercial buildings. We have, therefore, a very great artistic success. The building has a beginning, a middle and an end; its design is structural, for the great vertical lines correspond to the columns of the frame which are contained within the facing piers; the window space is ample and sufficient; the plan is employed in a natural manner as an important element of the design; the festal nature of the structure is sufficiently indicated in the ornamental balcony and belvedere; finally, the whole has been carried out with a consummate artistic feeling and appreciation of the problem, which is not only rare to find in works so utilitarian as this, but which we often look for in vain in structures of a purely artistic and ornamental nature.

Among the many notable commercial buildings illustrating the same principles of design by the same architects, I shall only have space to refer, in the briefest manner, to the Guaranty Building, at Buffalo. This is a 14-story, rectangular building, on an ample site. The basement is of 3 stories, the superstructure of 10, the frieze of 1. The leading element of the superstructure is the vertical lines of the piers between the windows, which, at the thirteenth floor, are connected by small, round arches, and, in design, are joined with the circular windows of the frieze. The whole of the surface of this building is covered with ornament; not structural ornament, as columns and pedi-

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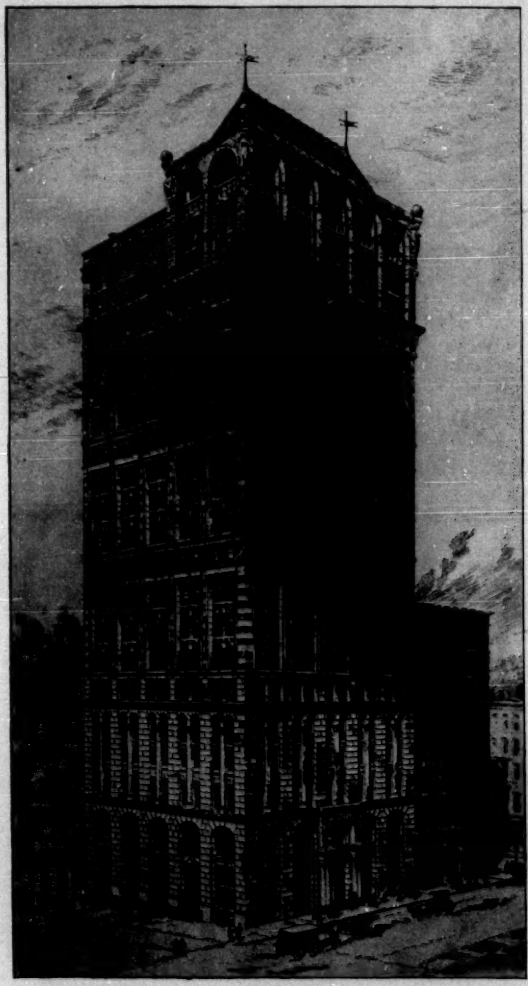

AMERICAN TRACT SOCIETY'S BUILDING, NEW YORK.

THE SCHILLER THEATRE, CHICAGO.

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ments, and other artificial additions, but a finely designed, carefully modelled surface ornament, very rich in detail, yet kept well within the structural lines of the architecture. Though possibly the most richly decorated commercial building in America, the skill of the artist has produced a design of structural sobriety with great richness of effect.

In both these designs, their success has depended, apart from the artistic feeling displayed in them, upon their unity. And this effect has been obtained, not only by the co-relation of the various parts of the façades to each other, but particularly by the long vertical lines of the superstructure, which naturally express the columns of the frame. That unity can only be obtained in a high design by unbroken vertical lines, is apparent in comparing either of Mr. Sullivan's buildings with one in which the horizontal lines predominate. The building of the American Tract Society, in New York, is a fair example of such a structure.

It is true, the design of the Tract Society's building is not devoid of some eccentricity; but as it is one of the highest and latest office buildings in New York, and reflects, moreover, the average principles of office design in that city, it may not unfairly be taken as a type of New York commercial design.

The building is a rectangle, with a small open court on the inner side adjoining the entrance front. Unlike many New York office buildings, the site is spacious, though its tremendous height of 23 stories has added to its apparent altitude. The most striking thing in this design is not its unity, but its diversity. We know it is a steel skeleton building, because no structure of this height would have been built on a site of this size in any other way; and, while there are no voids over solids, or solids over voids, there are no continuous vertical lines for a greater height than 3 stories in any part of the façades. The design, in fact, is not a single, homogeneous one, in which one part naturally develops into the other and each is related to the other, but instead, we have six great divisions piled one on top of each other, of independent design and without any relationship to any other part.

At the beginning we have a basement of 2 stories, and, as every building must have a base, this entirely fulfils the requirements of good design. But above this comes a three-story section which is not a basement, because it is cut off from the part below by a cornice, and is, moreover, 2 stories above the level of the street; nor can it be a superstructure, for the major part of the building is above it. It is impossible to give it a proper architectural name, though as it is of stone, like the two stories below, and the upper part of the building is of terra-cotta, it may, in the mind of its designer, have formed part of the basement. Over the cornice of this section is another section—a single story that appears to be an introduction to what is above it; then 3 stories with the windows enclosed within rectangular bays. A narrow string course runs below and above this part, and over it the same features are repeated; that is, the introductory story and the 3 stories in bays. And over this again they are repeated once more, cut off, as below, with horizontal lines, and forming sections complete in themselves. Over this is the heavy main cornice, supported on large brackets which entirely fill the space between the windows of another story. Here the building logically ends, for the cornice is naturally the finish of a building. But we have not yet reached the end, for above are more stories, with a great, porch-like erection in front, of applied columns carrying round arches, which are open and form a sort of belvedere; within these rises the hipped roof, which has a singular effect of growing out of the space behind the arches.

The error that led the designer of this building astray is very obvious; he did not understand the value of unity in a high building, and certainly did not know how to obtain it. Instead of unity, sobriety and strength, we have variety and change. The design is varied at every possible point, and cut up by horizontal lines and divided into shallow sections, in the false hope of making the building seem lower than it is. Yet it is part of its merits in the eyes of its owners that it is big: why, then, disguise this fact? And why, if it is a single building, and therefore a unit, mar its unity by cutting it into parts, and varying its design for

sheer sake of variety? The porch on the top is most unhappy in its effect: it completes the building, but only because there is nothing above it; it certainly is without relationship to what is below, nor are any of the lower sections related to any other part. There is ample material here for a good design; the architect has brought to his work a broad acquaintance with his art, and a fine mastery of detail, but he did not understand his problem. There is no structural significance in the design—simply a using up of space, and an evident fear of long, uninterrupted lines.

It would be easy to multiply examples of badly conceived designs for office buildings, or to name buildings that violate the rules of art more flagrantly than the one we have just studied, but this must suffice. It is folly to deny that the average artistic standard of design in the modern office building is not good. The "sky-scraper" has become a synonym for things of horror, and a blot upon the artistic aspects of our modern cities. That they are so is frequently true, but the error lies in the treatment, not in the dimensions of the buildings. Great office buildings like the Schiller Theatre, the Stock Exchange, the Auditorium, the Old Colony Building, the Monadnock Block and others, in Chicago; the Wainwright and the Union Trust, in St. Louis; the Mills Building, in San Francisco; the Guaranty Building, in Buffalo; the Union Trust Building, in New York; the Ames Building, in Boston, and some few others in these and other cities, show that, logically and artistically treated, the modern office buildings may be ornaments to our cities, and, by virtue of their art alone, take that supremacy to which, in the popular mind, they are entitled by reason of their size and their cost.

The last few years have witnessed a prodigious growth in the number of office buildings in the large cities of the United States. The architects have been eager to build them, for such costly work gives them more profitable employment than much of the lesser work they are usually engaged upon. They have become popular with investors; they have been used as an advertisement in displaying the wealth of their owners; they have become an integral part of our modern commercial life. But their artistic progress

has not kept pace with their structural development. The solution of the façade is not, indeed, yet to be found, for the vertical designs of many of the Western office buildings show the system to be followed in all high buildings, but the façade calls for a more rational treatment than has yet been given it in the larger number of instances. The duty of the architect, so far as artistic effect is concerned, is chiefly limited to the façade. The interior of the office building offers little to the visitor or the tenant in the way of artistic enjoyment. Well-lighted offices, ample elevator service, light corridors, convenient toilets, and abundance of sunlight, the best of ventilation, and a satisfactory system of heating and plumbing, are what the tenant requires more than decorated apartments. In buildings devoted, in part, to great corporations, the rooms of the company, as in the Manhattan and the Metropolitan Buildings, in New York, will be fitted up in a sumptuous fashion, regardless of expense. But these are private apartments, and form no part of the public features of the buildings. The entrance halls and elevator enclosures thus remain as almost the sole parts of the interior susceptible to artistic treatment. The value of a rich decoration for these parts has long been admitted by the architects and owners, and many splendidly decorated halls have been built in the larger office buildings.

The most notable of these is, without doubt, the interior court of the Metropolitan Building in New York, a superb apartment, lined with decorated marble, with delicate carving, with onyx and with bronze, with a disregard of cost and a sumptuousness of effect that is comparable only to the palatial architecture of Europe. That large expenditures are made for such decorative work as this speaks much for the general appreciation of art in the modern office building, and certainly the history of architecture offers few more striking contrasts than that between a palatial structure like the Metropolitan Building and the little 4- or 5-story buildings in which the merchants of a generation or less since transacted their business, and laid the foundations of the fortunes that, to-day, render our vast office buildings possible and profitable.

ACIDIMETRIC ESTIMATION OF VEGETABLE ALKALOIDS. A STUDY OF INDICATORS.*

By Lyman F. Kebler.

In volumetric analysis, the first question demanding attention is a suitable indicator or delicate end-reaction. The writer's object in this communication is to present the results of a study of five indicators in titrating alkaloids, in the hope that it may be of some service in formulating systematised methods of analysis in alkaloidal chemistry. The discordant analytical results often obtained by different chemists operating on the same sample are greatly to be regretted. It is the writer's opinion that the discrepancies are chiefly due to differences in *modus operandi*, to defective apparatus, and, in volumetric analysis, to different end-reaction tints arbitrarily assumed by each worker.

In order to eliminate as completely as possible the factors of uncertainty, the burettes and a pipette were carefully calibrated in order to ascertain the necessary factor for correction. A glass-stoppered cylinder was also standardised. All efforts to standardise a liter flask were thwarted. A large balance sufficiently sensitive to do the work satisfactorily could not be found.

In titration the personal equation plays an important part. Authorities are not agreed on end-reaction tints, each operator relying on his own judgment. The writer thinks it correct to titrate to the point where a different color from the initial color is developed. In this work[1] the writer titrated from acid to alkaline solutions as follows: Brazil

* Abstract of a communication read to the Chemical Section, September 17, 1895.

[1] Alkaloids, generally, are neutral to phenolphthalein, consequently it cannot be employed in titrating alkaloids directly. It is available for indirect titrations, *i. e.*, estimating the amount of acids combined with an alkaloid in its neutral salts.—L. F. K.

wood, from yellow to onion-red, the purple ultimately fading to this; cochineal from yellow to bluish-red; hæmatoxylin from yellow to brown-orange; litmus from red to onion-red, and methyl-orange from red to straw-yellow.

The indicator solutions were prepared according to the most approved processes. Cochineal and litmus, according to the specifications of Sutton's Volumetric Analysis, sixth edition. Phenolphthalein, 1 gram dissolved in 1 liter of 50 per cent. alcohol. Hæmatoxylin, well crystallised, 1 gram dissolved in 100 c.c. of strong alcohol. The method best suited for preparing the Brazil wood solution, is to place 3 grams of the wood into a casserole, add 10 c.c. of distilled water, boil gently for a few minutes, cool, and filter. A freshly prepared solution has given the writer the most satisfactory results. Methyl-orange, 1 gram dissolved in 1 liter of distilled water. Considerable difficulty was experienced in obtaining even a fairly satisfactory product of methyl orange. Reinitzer's[2] method for preparing the litmus solution did not come to the writer's notice until considerable work had been done with the solution prepared as above.

In titration, the following quantities of the several indicators were employed: methyl orange, Brazil wood, cochineal, and phenolphthalein, 5 drops each; litmus, 10 drops, and hæmatoxylin, 3 drops.

The standard solution, from which the exact strength of the other volumetric solution was determined, was a solution of normal sulphuric acid. This was prepared from data obtained by the several methods; titration against pure anhydrous sodium carbonate, using the above indicators; by precipitation as barium sulphate, and by Weinig's[3] process. The last method is simple, and gave the most satisfactory results. The following are the data obtained from an approximately normal sulphuric acid solution with the above methods:

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[2] *1894, Ztschr. angew. Chem.*, 547, 573; *Chem. News*, **70**, 225, 239, 249.
[3] 1892, *Ztschr. angew. Chem.*, 204; *Analyst*, **17**, 99.

Indicators, and Methods.	*No. of c.c. of Acid Solution required per 10 c.c. of Normal Sodium Carbonate.*	*Grams of SO_3 in 10 c.c. of the Acid Solution.*
Brazil wood	9·50	0·4211
Hæmatoxylin	9·54	0·4192
Cochineal	9·50	0·4211
Litmus	9·50	0·4211
Methyl orange	9·50	0·4211
Phenolphthalein	9·45	0·4216
Weinig's method	—	0·4247
Barium sulphate method	—	0·4200

Due precaution was taken to boil the solution thoroughly with the indicators requiring it. With solutions of the above strength it was impossible to detect any difference in the sensitiveness of most of the indicators.

With the normal sulphuric acid solution, a normal solution of pure potassium hydroxide was standardised. From the normal sulphuric acid solution and normal alkaline solution there were prepared, respectively, a decinormal acid solution and a centinormal alkaline solution. The two solutions thus prepared were carefully titrated against each other, employing the above indicators, with the following results:

Indicators.	*No. of c.c. of Normal Sulphuric Acid.*	*No. of c.c. of Centinormal KOH Required per 10 c.c. of Decinormal H_2SO_4.*	
		LaWall.	*Kebler.*
Phenolphthalein	10	101·80	102·00
Brazil wood	10	99·56	100·00
Cochineal	10	100·58	99·80
Hæmatoxylin	10	99·76	100·00
Litmus	10	99·97	99·60
Methyl orange	10	92·67	98·53

My associate, Mr. LaWall, took up a portion of the work independently, using the same solutions and apparatus. The above and all subsequent results are the average of duplicate, triplicate, or more titrations.

The titration of pure alkaloids, as found in the market, was next undertaken. With quinine and codeine the following method was used: 2 grams of the alkaloid were placed in the cylinder, dissolved in alcohol, and diluted with alcohol to 100 cubic centimeters. To 10 cubic centimeters of this solution and the requisite quantity of indicator con-

tained in a suitable beaker, the decinormal acid solution was added to slight excess, agitated, allowed to stand a few minutes, the sides of the beaker well washed down with distilled water, adding about 40 cubic centimeters, and the excess of acid titrated back with the centinormal alkaline solution.

With alkaloids not freely soluble in alcohol, the following procedure was adopted: 2 grams of the alkaloid were placed into a 200 cubic centimeter beaker, 75 cubic centimeters of decinormal acid added, the contents of the beaker warmed on a water bath, and occasionally agitated until the alkaloid was dissolved. The beaker and contents were then cooled, the contents transferred to a 100 cubic centimeter cylinder, the beaker carefully rinsed with several successive portions of water, transferred to the 100 cubic centimeter cylinder, and finally made up to 100 cubic centimeters with water. Each 10 cubic centimeters contained ·2 gram of alkaloid and 7·5 cubic centimeters of decinormal acid solution. After adding the requisite amount of indicator to 10 cubic centimeters of the alkaloidal solution, and diluting up to about 50 cubic centimeters, the excess of acid was carefully re-titrated. Two or more titrations were made in every case, with the same solution and indicator, by adding to the solution just finished another portion of the decinormal acid solution, and re-titrating with the centinormal alkaline solution, taking finally the average reading.

With quinine, strychnine, morphine and codeine, the following results were obtained:

	Quinine.		*Strychnine.*	*Morphine.*	*Codeine.*
Indicators.	*La Wall.*	*Kebler.*	*Kebler.*	*Kebler.*	*Kebler.*
Brazil wood	99·90	101·97	99·36	98·93	95·75
Cochineal	105·56	102·54	103·20	99·08	97·09
Hæmatoxylin	99·81	103·37	100·03	98·17	95·90
Litmus	101·80	103·55	103·54	98·93	96·38
Methyl orange	—	123·27	104·21	100·59	98·11

The analyst has rarely to investigate the purity of refined alkaloids, but the crude alkaloids claim a greater share of his time and attention.

The next step was to investigate the adaptability of the

above process to crude morphine and crude cocaine. The results are as follows:

Indicators.	*Crude Morphine.*		*Crude Cocaine.*
	La Wall.	*Kebler.*	*Kebler.*
Brazil wood	99·23	98·47	95·90
Cochineal	100·14	99·53	97·11
Hæmatoxylin	99·08	97·59	95·74
Litmus	99·50	98·93	96·82
Methyl orange	102·10	100·02	100·14

Notwithstanding the fact that crude alkaloids claim considerable attention on the part of the analyst, only a few are found on the market already extracted. It generally happens that the operator is required, not only to determine the amount of pure alkaloids, but also to extract them from their natural sources. For this purpose the writer employed a modification of Keller's process. The method is as follows: Place 10 grams of the dry drug into a 250 cubic centimeter flask, add 25 grams of chloroform, 75 grams of ether, stopper the flask securely, agitate well for several minutes, add 10 grams of 10 per cent. ammonia water, then agitate frequently and during one hour. On adding 5 grams more of 10 per cent. ammonia water and shaking well, the suspended powder agglutinates into a lump, the liquid becomes clear after standing a few minutes, and can be poured off almost completely.

(1) When the mixture has completely separated, pour off 50 grams into a beaker, evaporate the solvent on a water bath, add 10 cubic centimeters of ether, and evaporate again. Dissolve the varnish-like residue in 15 cubic centimeters of alcohol, with heat; add water to slight permanent turbidity, the requisite quantity of indicator and an excess of the acid solution; re-titrate with the centinormal alkaline solution.

(2) When the mixture has completely separated, pour 50 grams into a separatory funnel, treat at once with 20 cubic centimeters of acidulated water. After thorough agitation and complete separation, remove the aqueous solution into a second separatory funnel. Repeat the above operation twice more successively with 15 cubic centimeters of slightly acidulated water. The acidulated water in the second

separatory funnel is rendered alkaline with ammonia water, the alkaloid removed successively with 20 cubic centimeters, 15 cubic centimeters and 15 cubic centimeters of a mixture of 3 parts (by volume) of chloroform and 1 part of ether. Collect the chloroform-ether mixture in a tared beaker and distil off the solvent. The varnish-like residue is twice treated with 8 cubic centimeters of ether, evaporated on a water bath and dried to constant weight on the water bath. The varnish-like residue is next dissolved in 15 cubic centimeters of alcohol and treated as in (1) above.

Nux vomica and ipecac root were treated according to processes (1) and (2); belladonna leaves according to process (2). The results are as follows:

	Per Cent. of Alkaloids in Nux Vomica by Process (1).		*Per Cent. of Alkaloids in Nux Vomica by Process (2). Gravimetrically.*		*Per Cent. of Alkaloids in Nux Vomica by Process (2). Volumetrically.*		*Per cent of Alkaloid in Ipecac Root by Process (1).*	
	La Wall.	*Kebler.*	*La Wall.*	*Kebler.*	*La Wall.*	*Kebler.*	*La Wall.*	*Kebler.*
Brazil wood . .	2·04	2·58	2·94	3·00	2·37	2·37	2·46	2·54
Cochineal . . .	2·64	2·69	2·86	3·10	2·42	2·39	2·59	2·49
Hæmatoxylin .	2·18	2·24	2·88	3·11	2·23	2·27	2·48	2·54
Litmus	2·38	2·34	2·93	3·05	2·55	2·37	2·55	2·57
Methyl orange .	3·02	3·64	2·93	3·02	2·65	2·61	2·95	3·30

	Per Cent. of Alkaloid in Ipecac Root by Process (2). Gravimetrically.		*Per Cent. of Alkaloid in Ipecac Root by Process (2). Volumetrically.*		*Per Cent. of Alkaloids in Belladonna Leaves by Process (2'. Gravimetrically.*		*Per Cent. of Alkaloids in Belladonna Leaves by Process (2) Volumetrically.*	
	La Wall.	*Kebler.*	*La Wall.*	*Kebler.*	*La Wall.*	*Kebler.*	*La Wall.*	*Kebler.*
Brazil wood . .	2·58	2·60	2·36	2·35	0·26	0·20	0·19	0·15
Cochineal . . .	2·63	2·68	2·52	2·33	0·28	0·20	0·24	0·14
Hæmatoxylin .	2·58	2·68	2·35	2·33	0·27	0·22	0·21	0·13
Litmus	2·62	2·60	2·40	2·25	0·24	0·18	0·20	0·15
Methyl orange .	2·66	2·63	2·89	2·61	0·25	0·20	0·23	0·20

From the foregoing results it may safely be concluded that methyl orange cannot be numbered with the indicators suitable for titrating alkaloids. With centinormal, fifth decinormal and other solutions of various strengths, it fails to give satisfactory results. Notwithstanding the sensitiveness claimed for it, the writer believes that its days, as an ideal indicator, are numbered. Even Professor Lunge, the staunch advocate of methyl orange, has admitted that a properly prepared solution of litmus is superior to this indicator, in inorganic estimations.

Of the indicators thus far considered, hæmatoxylin, Brazil wood, and cochineal give very promising results. Hæmatoxylin is properly entitled to the first place, and Brazil wood to the second. Other indicators will be considered in due time.

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NOTES AND COMMENTS.*

ANNUAL REVIEW OF SCIENCE AND INDUSTRY.†

Iron and Steel.—After two years of almost continuous decline in output and prices, culminating, about the middle of 1894, in profound depression, the iron and steel trades of the United States began to exhibit signs of recovery, which, towards the middle of the year, assumed the proportions of a veritable "boom," both prices and production advancing at an unprecedented rate. The improvement noted, while affecting all branches, was most marked in the steel trade. In September, the production of pig iron was at the rate of 10,500,000 tons, the highest point ever reached. In November, it had reached the rate of 11,500,000 tons, which was maintained substantially to the close of the year. The steel trade has met with somewhat of a check; but as regards manufactured products—bar iron, structural forms, etc.—the greater portion of the improvement made earlier in the year was maintained at the close.

A conspicuous feature of the trade, which has been emphasised by the events of the past two years, is the rapid extension of the demand for iron and steel for various structural uses, and the relative decrease of the demand for railroad uses. The railroads, which, until recently, were the greatest consumers of steel, in the recent developments of the trade, have been relegated to a subordinate position; partly, it may be explained, on account of the business depression which the railroads have felt most severely; but partly, also, because of the actual growth in the uses of steel for building and other miscellaneous purposes.

The falling off in the consumption of rails is explained by the figures of new railroad construction, which declined, in 1895, to the lowest point for thirty years. The most reliable authority gives the new mileage of 1895 as 1,300 miles, as compared with 1,760 miles reported in 1894. The severe economies which the railroads were compelled to put in practice, and which reduced the demands for repairs and renewals of permanent way and rolling stock to the lowest figures, have also had their share in lessening the consumption from this source.

It is yet too early to give with accuracy the figures of production of iron‡ and steel, but it is safe to say that, in the items of pig iron and ingot steel, they will be found to have equalled the best previous record. With the return of business to normal conditions, it needs no special foresight to predict an expansion of these important industries that will eclipse even the remarkable growth of the past decade.

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* From the Secretary's monthly reports.

† An abstract of the report of the Secretary to the annual meeting of the Franklin Institute, held January 15, 1896.

‡ Since writing the above, we have observed an estimate of pig iron production, made by the *American Manufacturer*, of Pittsburgh, which confirms the opinion above given. The *Manufacturer's* figures place the pig iron output for 1895 at 9,387,639 tons, which exceed those of 1890 (heretofore the year of heaviest production) by about 185,000 tons.

Gold.—There is every reason to believe that the world has just entered upon a period of enormously increased gold production, which promises not only to rival or even greatly exceed the greatest output of the best days of California and Australia, but which promises also to continue in an increasing ratio for many years to come. The financial and commercial influences of this impending deluge of the precious metal, in the opinion of experts, cannot fail to be profound and far-reaching. The statistics of gold production for the past year exhibit a largely increased yield from all the leading mining regions. The greatest increases, however, are shown by the yield of the Transvaal district in South Africa, and of Colorado in the United States. The greatly increased demand for gold throughout the civilised world, which has stimulated the search for new deposits, and the introduction of improved processes whereby enormous deposits of low-grade ores—heretofore valueless—can be profitably mined, are the chief factors of this most important development. It may be of interest to note, in passing, that, in the past year, the United States once more resumed the first place among the gold-producing countries, which for a time had been held by Australia, while Africa advanced to the second place.

Electric Railways.—Notwithstanding the prevalence of unfortunate business conditions, the extension of the electric railway throughout the country continued without evidence of abatement. It is estimated that the additions to electric lines in the United States in 1895 were not less than 1,800 miles, as compared with 1,500 in 1894. About one-fourth of this may be referred to new railways, and the remainder to the changing from animal to electric traction by existing roads.

A highly important development is the adoption of the electric system of traction by several of the steam railways. The Nantasket Beach branch of the New York, New Haven and Hartford Railroad was operated by electricity during the past year, and the introduction of a 95-ton electric locomotive for the hauling of heavy trains in the Baltimore and Ohio tunnel at Baltimore attracted much comment. The success which has attended these experiments has given rise to an unusual amount of discussion respecting the future possibilities of electricity in railroad work. A significant circumstance in connection with this phase of the subject is the reported combination of the interests of the Westinghouse and Baldwin Companies for the manufacture of electric locomotives.

The most important item in this field was the completion and opening for public service of the elevated electric railway system in Chicago, referred to in my last year's review. The system of under-surface or conduit traction for electric railways, also has been brought into prominence by the results of experiments, during the past year, on the Lenox Avenue road in New York, and by the successful operation of the Connett-Budapest system in Washington. The outcome of the New York experiment is the official announcement that this or a similar system will shortly be adopted by all the important surface roads in that city; and, speaking in general terms, the experience gained in these trials appears to have demonstrated that the difficulties involved in under-surface electric traction have been greatly overestimated.

Electric Power Transmission.—The most interesting event in the electric field that occurred during the past year was the starting of the great Niagara Falls Power Plant, which has been the subject of numberless articles in the technical press of the world. It will be unnecessary to make further reference to this subject here, save to say that the carefully made plans of the engineers in charge of the work, prominent among whom was, and is, Dr. Sellers, the distinguished professor of mechanics in this Institute, appear to have proved highly successful. The large turbines and generators are now delivering current to a number of manufactories established on the ground, and the extension of the transmission to Buffalo—twenty-two miles distant—awaits only the settlement of the terms of contract. The successful demonstration at Niagara will, no doubt, give the needful stimulus for the erection of power transmission plants in numerous other localities, favorably situated in respect of water powers. Several projects of this character now under consideration were referred to in last year's review.

Electro-Metallurgy.—During the past year great interest was aroused by the announcement that Mr. Thomas L. Willson had developed an electric furnace process adapted for the production on the commercial scale of calcium carbide. The special interest attaching to this announcement grows out of the fact that calcium carbide furnishes a source from which acetylene gas may be obtained by simple interaction with water. Acetylene gas possesses extraordinary illuminating qualities, and the promoters of Mr. Willson's patented inventions bearing on the subject have declared that they are able to manufacture the carbide at a cost sufficiently low to place acetylene gas upon the market as a competitor of other illuminating systems. The actual demonstration of this claim would unquestionably be followed by extensive and decided changes in the field of illumination. For the present, however, it would be safest to suspend judgment on the question and to await developments, especially since, on this all-important question of cost of producing the raw material there exists among experts the widest diversity of opinion, and theory based on thermo-chemical considerations affords us no trustworthy ground upon which to base estimates of output.

When the conditions which prevail in the electric furnace are as well understood as those of our well-known metallurgical furnaces, many problems, now obscure, will be satisfactorily solved, and we shall have tenable ground to stand upon in making predictions based on relations between the heats of formation of the novel compounds formed in the electric furnace and the energy consumed. Thus far, however, the controlling data needful for the understanding of the reactions that take place under these circumstances are wanting.

It would be highly imprudent, however, to ignore the fact that the probabilities are all in favor of a better understanding, and more perfect control of this new and remarkable adjunct in metallurgical operations, and that the immediate future may witness advances of an astonishing nature in electric furnace methods and results.

In the *electrolytic branch of electro-metallurgy* the progress of the past year has been rather in the direction of extension and improvement of methods than in new discovery.

The aluminum industry has been greatly stimulated by the starting of the new works of the Pittsburgh Reduction Company at Niagara, and by the enlargement of the works of the Neuhausen Company in Switzerland. These and other enlargements of existing works have greatly increased productive capacity, the immediate effect of which has been a reduction in the selling price of the metal, and this in turn must have, as its natural outcome, the finding of new uses for it. It is not unlikely, from present indications, that we may have aluminum selling at 25 cents a pound within a short time. There is nothing that could illustrate more strikingly than the history of the aluminum industry the rapid and substantial advance of electro-metallurgical methods. But little more than ten years ago, aluminum was selling at $10 per pound, and the consumption was about 5,000 pounds per year. At present it can be had for 35 cents per pound, and the consumption is at the rate of more than 1,000 tons per year, and is rapidly growing.

The establishment at Niagara of a large plant for the manufacture of the new abrasive material—carborundum—an electric furnace product, is a circumstance worthy of note. This product has some highly interesting properties, and appears to have firmly established its reputation as a valuable addition to the list of abrading substances known in the arts.

The *chemical industry* has also been the gainer by the successful introduction, in England, of a process devised by Mr. H. Y. Castner for the production of caustic and chlorine by the electrolytic decomposition of common salt. The solution of this problem has been sought by a number of inventors; but until the announcement of Mr. Castner's process and results, the success of the electrolytic methods has been regarded as very doubtful. The results already demonstrated by the improved methods here referred to are extremely promising, and the opinion of experts best qualified to judge of them is highly favorable. Some, indeed, do not hesitate to say that in ten years the electrolytic methods for soda and bleach will have practically supplanted the Leblanc and Solvay processes that now have possession of the field.

It is worthy of notice that arrangements have been concluded for the introduction of the Castner electrolytic process in the United States, and that a plant of this kind, now being erected at Saltville, Va., will probably go into operation during the present year. Electrolytic processes as applied to the bleaching of textile fibres, the production of chloroform, potassium chlorate, ozone, etc., have fully demonstrated their commercial value, and have taken rank among established industries.

In *telegraphy*, the improved system of Mr. P. B. Delany has been so recently described and illustrated in this hall that a mere brief reference to it will suffice at this time. Mr. Delany's machine system of recording and transmitting messages appears to contain all the elements of remarkable simplicity and high efficiency, notably in respect of speed in transmission, needed to enable the telegraph not only to hold its own against the competition of the telephone and other means of rapid communication, but also to take possession advantageously of a considerable portion of the mail service.

Direct Conversion of Heat into Electricity.—In the direction of cheapening the cost of generating electricity, by the conversion of heat into

electric current directly without the intervention of the steam engine, some progress appears to have been made in increasing the efficiency of the thermo-pile; but the anticipations of those who had hoped for improvement in the direction of obtaining electricity directly from the combustion of coal, have met with disappointment. The experiments of Borchers with a gas battery deriving its electro-motive force from the oxidation of carbonic oxide, and which apparently demonstrated the feasibility of attaining the object aimed at by indirect means, have been subjected to searching criticism, and his results—if not actually invalidated—have been rendered doubtful. The problem, though admitted on theoretical grounds to be possible of solution, remains yet as perplexing as ever.

The proposition confronting the electrician has been concisely stated by Mr. C. J. Reed, a member of this Institute, in the following terms: "The problem is the conversion of the energy of fuel (including fuel gases, such as carbonic oxide and hydrocarbons) into electrical energy by oxidation, without transforming the energy into heat, and without the destruction of chemical reagents or the formation of waste products that require regeneration." In discussing the subject in a recent paper, published in *Cassiers' Magazine*, Dr. Duncan summarises the question in the following terms: "As to the possibility of solving the problem, he would be a rash man who would deny that in the future some one, by accident or by reasoning based on a fuller knowledge of electro-chemistry, might disclose a successful process. * * * I am myself confident that it will be discovered. Many men, most of them poorly equipped for the work, have been engaged on the problem, and some progress has been made. As for the method of solution, it must be remembered that the problem is: Electricity must be produced and nothing but fuel and air must be consumed. This points to two methods: either a gas battery must be used, or some substance must be discovered which will, in some way, convey the oxygen of the air to the carbon, without being itself decomposed." * * * "Finally, my conclusions are: (1) That the problem will be solved; (2) that the solution will be a simple one; * * * (3) that it will destroy the boiler and engine industries, and will seriously affect parts of the electrical industry; but it will cause a development in applications of electricity, far-reaching and helpful in the end to humanity."

Engineering.—In the field of engineering, perhaps the most notable event was the formal dedication to traffic, with imposing public demonstrations, of the ship-canal connecting the North Sea with the Baltic. The length of this artificial waterway is $61\frac{3}{10}$ miles; its cost was $39,000,000.

The completion of the Harlem Canal, uniting the East and North Rivers, is a circumstance of much more importance from the commercial and strategic standpoints than its magnitude or cost would indicate.

Worthy of special mention among engineering works in progress, is the great drainage canal of the city of Chicago, to which several extended references have lately been made in the *Journal*, and which is rapidly approaching completion.

The Nicaragua Canal project, for which at one time the outlook appeared highly favorable, has fallen upon evil days. Difficulties of a financial nature

compelled the abandonment of active work some time ago, and the report of a Commission of Engineers, appointed by the Congress to investigate the company's plans and estimates, is currently believed to be of an unfavorable character.

At length, the long-mooted project of tunnelling the Simplon Pass has assumed definite form, the contract for the work having been let during the past year for the sum of $13,750,000. When completed, this tunnel will outrank all others in magnitude. It will be 12¼ miles in length, and will comprise two tunnels, spaced 56 feet apart, one for each line of rails.

Among railroad enterprises, the only item of prime importance to be noted is the steady progress made upon the great Trans-Siberian Railway which the Russian Government has been steadily pushing towards completion for a number of years, and which in due time will doubtless play an important part in the development of that great empire's Asiatic possessions.

It is, however, in the department of *naval and military engineering* that the greatest advances have been made. The persistent rivalry between the leading military powers has led to the construction of floating fighting machines of marvellous powers of offence and defence. The advances relate equally to the size and speed of warships, to improvements in the defensive qualities of armor and in the offensive power of guns and projectiles. It seems a singular perversion of the order of things that so much of the best effort of modern science should be devoted to the improvement of engines of destruction; but after all, the outcome may, and not unlikely will, be the speedier coming of the era of universal peace and good-will among the nations through the very agency that is constantly striving to make war more frightfully destructive.

One of the most interesting mechanical developments of the past year was the sudden coming into prominence of the self-propelling vehicle. The subject appears to have been attracting considerable interest in Europe, notably in France, for several years. Attention was first directed to the matter by the announcement of a public competition between representatives of the several classes of such vehicles in a trial race between Paris and Bordeaux, a distance of 358 miles. The performance of a number of these motor wagons demonstrated that a creditable degree of efficiency had already been reached in their construction and management.

The sudden awakening of interest in this subject which this event created in this country was demonstrated when one of the Chicago daily journals announced a prize competition for self-propelling vehicles, to take place in the autumn of last year. In both the number of competitors and the high grade of the vehicles entered in this trial, the event was remarkably successful, although the almost impassable condition of the road between Chicago and Milwaukee rendered it impossible to learn much about their relative merits in actual road performance. The first honor in this competition, it is interesting to note, was awarded to an electrically propelled vehicle, the power for which was furnished from storage batteries. To what extent the development of the self-propelling vehicle will be carried in the imme-

diate future is, of course, problematical. There are substantial reasons, however, for the opinion that its use will rapidly extend, and that it will presently find a recognised place among the mediums of transit in town and country. In this country, unfortunately for the speedy success of such a movement, it will find itself handicapped, except in the immediate neighborhood of the large cities, by the wretched condition of the public highways. On the other hand, should it arouse only a moderate portion of the enthusiasm which is accorded to the bicycle, it may prove of substantial benefit in advancing the cause of good roads throughout the country.

In the field of *pure chemistry*, the greatest interest attaches to the verification of the discovery of "argon," a new constituent of the atmosphere, which Lord Raleigh and Professor Ramsey announced towards the close of 1894. The doubts that were at first expressed, respecting the genuineness of this notable discovery, have since been completely dissipated by the brilliant experimental work of those investigators who have isolated the new element and determined its constants. The fact that a hitherto unsuspected element —"argon"—forms a constituent of the atmosphere to the extent of 1 per cent. is now placed beyond question.

Professor Ramsey has added to the laurels gained in this classic research by the discovery of another new element found in the rare mineral clèveite. This element he succeeded in identifying, by its spectrum, with the hypothetical solar element, to which Mr. Lockyer, many years ago, gave the name of "helium."

CONDITION OF CARBON IN THE ELECTRIC ARC.

In a recent Cantor lecture before the London Society of Arts, Prof. Silvanus P. Thompson affirmed that the carbon in the crater of the electric arc was actually in the liquid state, and that the well-known phenomenon of the hissing of the arc is caused by the violent and noisy boiling of the liquid carbon. He adduces the following facts in support of this interesting view:

"Captain Abney had found the white surface of the luminous crater to be always of an equal degree of whiteness, which obviously means that it is always of an equal degree of temperature. * * * The only thing that could account for there being a fixed temperature for the crater surface was the fact that carbon is at the surface in a state of volatilisation; that the carbon is evaporating off from the positive carbon into the arc or flame. At that surface you necessarily must have the temperature at which carbon evaporates, just as you cannot have the surface of ice under ordinary conditions either hotter or colder than the temperature which is taken as zero of the Centigrade scale. * * * My present view of the physical state of the arc crater is that the solid carbon below is covered with a layer or film of liquid carbon just boiling or evaporating off.

"When hissing takes place, a new state of things is set up. If you watch a short, hissing arc, you will see a column of light concentrating itself on a narrow spot, and the spot keeps moving about, and is very unstable in position, as well as in the amount of light it gives out. The contracted spot from

which light seems to start pits deeper into the carbon. * * * Mrs. Ayrton * * * made the observation that the crater surface, after the arc has been hissing, is found to be literally honeycombed. When the arc is hissing, you can see little bits erupted out, and the hissing seems to be comparable to the hissing which takes place in water just when it is beginning to boil. If you have some water being heated in such a way that there is not more than a certain quantity of heat given off from the surface, you have the water evaporating quietly, but you cannot get more than a certain quantity of heat given off per square inch of top surface of the water in that quiet way. If you force more than a certain quantity of heat to pass off per top square inch of the water, you find the water begins to break up internally, and you have bubbles formed below the surface; the surface breaks up, the bubbles are thrown out, and you have a noisy phenomenon. I think you will find there is exactly the same kind of difference between the silent arc and the hissing arc as between quiet evaporation and a noisy boiling. When the arc is hissing, there is a sort of decrepitation, as though solid particles were being torn asunder to make way for something coming out."

EFFECT OF THE DROUGHT ON RIVER TRAFFIC.

The prolonged drought which prevailed from midsummer into early autumn, over the eastern section of the country, caused a serious interruption of the traffic upon many of the rivers. Its effect upon the coal trade is set forth in the following brief statement, which appears in a recent impression of the *Bulletin* of the American Iron and Steel Association:

"Among other damage done by the long and severe drought of the fall of 1895, was a total interruption in the shipment of coal from the Monongahela region down the Ohio River. A few days ago there were loaded in barges in the Pittsburgh harbor, and awaiting shipment on the first rise of the river of 12 to 15 feet of water, over 1,300,000 tons of coal, railroad iron, barbed wire, nails, and other commodities, equivalent to 43,333 carloads of 30 tons each, or 1,445 trains of 30 cars each. It has been calculated that if the trains were placed one after another in a solid train the locomotive would enter Cincinnati as the caboose was leaving Pittsburgh. The coal trade of the Kanawha region in West Virginia was also injured by the long drought. It is said that there were 7,317,000 bushels of coal in 509 boats and barges lying in the Kanawha River pools, waiting for a rise."

TEST OF SELF-PROPELLING VEHICLES.

The competitive trial of self-propelling vehicles, arranged by the Chicago *Times-Herald*, took place on Thursday, November 28th. The course of the trial race was from Chicago to Milwaukee, a distance of 54 miles. Only six machines actually took part in the trial. A much larger participation had been expected, but unreadiness and the wretched condition of the roads—which for miles "were unbroken snowbanks and slush"—were responsible for the non-appearance of a number of those announced as competitors.

The competing machines were the Duryea, of Springfield, Mass.; the Morris-Salom "Electrobat," of Philadelphia; the Mueller Motocycle, of Decatur, Ill.; the Macy, New York; De la Vergne, New York; Sturgis Electric Motocycle, Chicago.

Two of the machines only, both of them belonging to the class of petroleum motors, covered the entire distance. The first to reach the goal was the gasoline motocycle of Chas. E. Duryea, of Springfield, Mass., which covered the distance in 10 hours and 23 minutes. This is considered a highly creditable performance, in view of the condition of the roads.

The Mueller vehicle made the journey in 11 hours, 58 minutes. The other machines were taken over part of the course and withdrawn. The winning machine, notwithstanding the severity of the trial to which it was subjected, appeared to be none the worse for its work—a fact which speaks well for its design and construction, since the storm of the previous day is said to have had completely paralysed traffic in that district.

The outcome of these trials is unanimously conceded to have demonstrated the real value of the automobile vehicle, and the belief appears to be very generally entertained that the immediate future will witness the very general introduction of this form of vehicle. The advantages that would be derived from the general use of such vehicles, when considered only from the sanitary standpoint, would be very great; and, from the economical point of view, the problem would seem already to have been solved. W.

TECHNICAL NOTES.

A Scotch engineer, Mr. Smillie, has invented *a new steam pipe*, capable of withstanding extremely high temperatures. He winds a close coil of steel wire about a copper tube and solders the whole firmly by immersing the steel-wound pipe in a fusible alloy, which has a melting point above the temperature of the steam which it is to convey.

A new method of *soldering lead to lead* consists in using an amalgam of the metal. The two surfaces to be united are first cleaned by scraping; then there is interposed between them a thin layer of lead amalgam. The soldering iron is then passed over the line of junction. The heat liberates the mercury of the amalgam, and the finely divided lead, set free from the mercury, fuses and solders the two sheets.

The Mannesmann Tube Company (Germany) has built for its works a huge *wire fly-wheel*. It is described as being formed of a cast iron hub or boss, to which are attached two steel-plate discs or cheeks, about 20 feet in diameter. The peripheral space between the discs is filled in with some 70 tons of No. 5 steel wire, completely wound around the hub, the tensile resistance thus obtained being found to be far superior to that of any casting. This huge fly-wheel is driven at a speed of about 240 revolutions per minute, giving a peripheral velocity of 2·8 miles per minute, or, approximately, 250 feet per second.

BOOK NOTICES.

The Encyclopædia of Founding, and Dictionary of Foundry Terms Used in the Practice of Moulding, etc. By Simpson Bolland. First edition, first thousand. New York: John Wiley & Sons, 1894.

This work presents a brief encyclopædic description of the materials, tools, machinery and methods employed in the art of casting in all the useful metals. It includes, also, many useful formulæ in connection with the manipulation of metals in soldering, brazing, turning, galvánising, plating, refining, smelting, etc.

It will be found very useful to all who may have to do with these arts, whether as artisan or engineer. The present work may be regarded as supplementing the earlier works of the same author on foundry practice, which have met with a favorable reception. W.

Practical Instructions in Quantitative Assaying with the Blowpipe; containing, also, readily applied qualitative blowpipe tests. For the prospector, miner and assayer, and for use in colleges. By E. L. Fletcher, U. S. A. New York: John Wiley & Sons, 1894. (Price, $1.25.)

The author has endeavored in this volume to meet the demand for a condensed, practical and cheap hand-book on blowpipe assaying, adapted to the wants of the prospector, miner, and, incidentally, for students of mineralogy. It covers qualitative and quantitative methods suitable for the determination of minerals, ores and metals. Wet methods have been excluded, except such as are indispensable in parting in the gold assay and in the standard flame reactions. The author particularly commends the use of the Fletcher blowpipe furnace.

The book is well adapted for its intended purpose. W.

Justus von Liebig: His life and work. 1803–1873. By W. A. Shenstone, F.I.C., etc. New York: Macmillan & Co. 1885. Price, $1.25.

The Herschels and Modern Astronomy. By Agnes M. Clerke. New York: Macmillan & Co. 1895. Price, $1.25.

The two works above named are recent contributions to the "Century Science Series," edited by Sir Henry E. Roscoe, a series of biographical sketches of scientific worthies, written in a popular style, excellently adapted to familiarise the non-scientific reader with the works of the master minds who have contributed so largely to our intellectual advancement and material welfare. W.

The Horseless Age. A monthly journal devoted to the interests of the motor vehicle industry. Vol. 1, No. 1. November, 1895. New York: E. P. Ingersoll, 157–159 Wall Street. Price, $2 per year; single copies, 25 cents.

Journalistic enterprise is again strongly in evidence in the launching of a new journal devoted specially to the interests of an industry, as yet in its

infancy, but which gives promise of lusty growth. From the widespread attention which the subject of motor vehicles is attracting, abroad and at home, there is little room for doubt that we will witness, in the next decade, great improvements in their construction, with a corresponding extension of their use for business and pleasure. The developments of the self-propelling vehicle may, indeed, rival that of the omnipresent bicycle in the past decade, whose popularity it seems not unlikely to share.

The enterprising publisher of *The Horseless Age* is evidently determined to take time by the forelock and to keep pace with, rather than to follow, the course of this unique industrial departure. If he has read the signs of the times aright, there should be a great future for his journal.

The initial copy before us makes a large quarto of some fifty pages, most of which are devoted to illustrations and descriptions of various forms of motor vehicles. It is well printed and makes a handsome appearance.

W.

Manual of Physico-Chemical Measurements. By Wilhelm Ostwald, Professor of Chemistry in the University of Leipzig. Translated, with the author's sanction, by James Walker, D.Sc., Ph.D., etc. London and New York: Macmillan & Co. 1894. Price, $2.25.

The present work is an admirable addition to the limited number of aids available to the chemist and physicist in performing physico-chemical measurements. The domain of physical chemistry, of late years, has grown so rapidly, and the methods and appliances have multiplied so greatly, that a work of this kind, which describes the newest methods of measurement, will prove very serviceable alike to the chemist, the physicist and the engineer.

W.

A Hand-Book for Surveyors. By Mansfield Merriman, Professor of Civil Engineering in Lehigh University, and John P. Brooks, Instructor in Civil Engineering in Lehigh University. First thousand. New York: John Wiley & Sons. 1895.

The present volume, which appears as a pocket-book containing 128 pages of text and 114 pages of tables, is a valuable addition to the extremely useful series of works which have already made Professor Merriman's name familiar to the engineering public.

It is designed for the use of classes in technical schools, and also as a field-book for surveyors, and the effort of the authors to discuss clearly and concisely, in accordance with the best-known methods, each of the topics involved, namely, land and town surveying, levelling and simple triangulation and topography, has resulted most successfully.

A separate chapter is devoted to each of these topics. The first, covering the fundamental principles, embraces what is deemed needful of the elements of geometry and trigonometry, and of mensuration as applied to the problems arising in surveying.

The second chapter contains a brief description of a few of the instruments in most common use, and takes up in detail, as an example, the survey

of a farm. The surveys of United States public lands are also here described and illustrated.

Chapter II, on levelling and triangulation, embraces a discussion of the level and its adjustments and uses, and of the adjustment and comparison of transits and of tapes.

The book is provided with a set of trigonometrical and other tables, including a table of azimuths of Polaris at elongation on January 1st, from 1895 to 1910, and Professor Winslow's tables for the reduction of stadia readings. T.

Problems in the Use and Adjustment of Engineering Instruments. Forms for Field-Notes. General instructions for extended students' surveys. By Walter Loring Webb, C.E., Assistant Professor of Civil Engineering in the University of Pennsylvania. First edition. First thousand. New York: John Wiley & Sons. 1895.

The author here presents a series of problems to be worked out by the student in the field. His aim is, not to replace any general text-book on surveying, but "to supplement the general instructions of such text-books by such general directions that the student may work *alone*, aided only by such occasional help as may be given by one instructor looking after several parties."

The problems embrace linear measurements, chain surveying, compass, level, transit, plane table, sextant and barometric practice, the use of the planimeter and pantograph, and railroad surveying.

No attempt is here made to describe the instruments used, as the student is supposed to be already familiar with their construction and operation.

T.

Stand-Pipe Accidents and Failures in the United States. A chronological record of accidents, etc. By Wm. D. Pence, C.E., Assistant Professor of Civil Engineering, University of Illinois. With 37 illustrations, numerous tables and an index. New York: Engineering News Publishing Company. 1895. Price, $1.00.

The growing frequency of accidents to waterworks' stand-pipes has forced upon the attention of engineers the conviction that there must be something wrong either in the theoretical assumptions involved in their design and construction, or in the manner in which they are used, and the aim of the author in compiling a chronological record of accidents to, and failures of, stand-pipes in the United States has been to subject the facts and data gathered to careful analysis, with the view of finding a rational explanation of each case, and thus laying a foundation for the proper criticism of accepted theories and practice. The author's work has been carefully and intelligently done, and he has laid the engineering fraternity under obligations. W.

Franklin Institute.

[*Proceedings of the annual meeting, held Wednesday, January 15, 1896.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 15, 1896.

MR. CHARLES BULLOCK, Vice-President, in the chair.

Present, 61 members and 12 visitors.

The Secretary presented the annual reports of the Board of Managers, the Committee on Library, the Committee on Science and the Arts, the Chemical and Electrical Sections, and the Trustees of the Edward Cresson Medal Fund, which were accepted.

Mr. Lewis Nixon, late naval constructor, U. S. N., read a paper on "The Marsden Corn-Pith Cellulose," a new substance claimed to possess remarkable water-excluding properties. Mr. Nixon exhibited specimens of the product, and gave an illustration of the avidity with which it absorbed water. Some discussion followed the reading of the paper. The subject was referred for investigation and report to the Committee on Science and the Arts.

The Secretary presented his annual report, embracing a *résumé* of industrial progress. The tellers of the annual election made their report, whereupon the following members were declared elected to the offices set opposite their names, viz.:

For *President*	(to serve one year), . . .	JOSEPH M. WILSON.
" *Vice-President*	(" three years), . . .	CHAS. BULLOCK.
" *Secretary*	(to serve one year), . . .	WM. H. WAHL.
" *Treasurer*	(" " "), . . .	SAMUEL SARTAIN.
" *Auditor*	(" three years), . . .	SAMUEL H. NEEDLES.

For *Managers* (to serve three years).

WM. L. BOSWELL,	ISAAC NORRIS,
THOS. P. CONARD,	THEO. D. RAND,
JAS. M. DODGE,	STACY REEVES,
HENRY GAWTHROP,	COLEMAN SELLERS,

For members of the *Committee on Science and the Arts* (to serve three years).

ARTHUR BEARDSLEY,	G. M. ELDRIDGE,	C. J. REED,
HUGO BILGRAM,	F. L. GARRISON,	E. ALEX. SCOTT,
FRANK P. BROWN,	W. N. JENNINGS,	COLEMAN SELLERS,
JOHN H. COOPER,	ARTHUR KITSON,	H. W. SPANGLER,
N. H. EDGERTON,	EDWARD F. MOODY,	WM. H. WAHL.

On Mr. Fullerton's motion, duly seconded, it was

Resolved, That the question of the expediency of permitting members to vote at the annual election by letter-ballot be referred to the Board of Managers for consideration, and report to the Institute.

Adjourned.

WM. H. WAHL, *Secretary*.